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DÉCEMBRE 1927

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IMPRIMERIE BIANCO LUNO

An account of the Work which Spain has carried out in the Atlantic Ocean and the Straits of Gibraltar.

By

Professor **Rafael de Buen,**

Chief of the Scientific Staff at the Dirección General de Pesca.

Oceanographical and marine biological work in Spain have been intimately affected by the creation of the "Instituto español de Oceanografia", thanks to which marine investigations are carried out with ever increasing intensity, adhering to and collaborating in the work of the three great international commissions which exist in Europe: the "International Council for the Exploration of the Sea", the "Oceanographical Section of the Geodesical and Geophysical Union", and the "International Committee for the Scientific Exploration of the Mediterranean".

The "Instituto español de Oceanografia" was created by the Royal Decree of the 17th April, 1914, and the laboratories already in existence at Santander, Palma de Majorca and Malaga were incorporated in it. At first the Institute came under the jurisdiction of the "Ministerio de Instrucción Pública", but later by Royal Decree of the 5th June 1924 it became a part of the "Dirección General de Pesca", (a department of the "Ministerio de Marina"), the object pursued by the new organisation being the placing of oceanographic science at the service of the rich fisheries which are of such great importance to Spain.

In the publications of the "Instituto español de Oceanografia" will be found an account of the intensive work which has been carried out during some twelve years, that is to say in the notes and articles which have appeared in the "Boletin de Pescas", the "Memorias", the "Notas y Resumenes" and the "Resultados de las compañas realizadas por acuerdos internacionales", which have in the main formed the basis of the present article.

Since Atlantic problems especially are of interest to the scientific experts of the International Council for the Exploration of the Sea, we must deal almost exclusively with that Sea, leaving almost entirely on one side the extensive work which has been done in the Mediterranean and the publications which as a result of this work have appeared from time to time.

The first Spanish campaign in the Atlantic organised by the "Instituto español de Oceanografia" took place in 1916, and the work has been carried on almost without interruption since that date, more especially off the coasts of Galicia, Asturias, Santander and the Basque provinces, as also in the Straits of Gibraltar and the Bay of Spain.

Before proceeding with a detailed account of results, we will give a summary, necessarily brief, of the results of the different campaigns undertaken in the Atlantic.

1916. During July and August work was carried on off the estuaries of Galicia, where the fisheries are of considerable importance, from the gunboat "Hernan Cortés". The greater part of the work was done off the Vigo estuary, and in a lesser degree off the Marin and Arosa estuaries. The number of operations was 378, of which 56 were captures of plankton and fish.

1917. The work was carried out on the cruiser "Rio de la Plata" and the naval auxiliary "Primero de Meira" off the estuaries of the south of Galicia. It was, however, confined to the coastal zone, since the sad events through which Europe was passing prevented work being carried on outside territorial waters. The work was done in the spring and summer, the number of operations amounting to 339, of which 60 were of a biological nature.

1918. The coasts of the N.W. and N. of Spain were visited in July, August and September in the gunboat "Hernan Cortés", from the mouth of the Miño as far as Santander; 335 operations were carried out of which 61 were of a biological nature. Depths down to 1500 metres were reached with nets.

1920 and **1921.** In the course of the work, which was performed with the aid of the naval despatch-boat "Giralda", a number of observations were made between the Straits of Gibraltar and Lisbon. On this occasion Spain was honoured by the presence on board of his Highness Prince Albert I of Monaco, accompanied by the eminent French oceanographers Prof. Thoulet, Dr. Richard and H. Bourée.

Later, at the end of 1920 and the beginning of 1921, work was carried on in the Straits of Gibraltar, and though the persistent bad weather made it impossible to obtain the results desired, important ground work

was completed which served as a basis for the intensive investigations carried out in that zone in 1922 and 1923.

1922. With the little motor boat "Averroes", belonging to the Malaga laboratory, continuous work was carried out throughout June and July in Algeciras Bay. 323 operations were completed, all of which were of an oceanographical character.

The oceanographical study of the Bay of Algeciras has served as a basis for the explanation of the complicated dynamic mechanism of the Straits of Gibraltar. From that work we may indeed date the beginning of our knowledge of the phenomena which arise as a result of the interchange of water between the Mediterranean and the Atlantic.

1923. The campaign undertaken in this year from April to August with the naval transport "Almirante Lobo" gave the most important results hitherto obtained by the "Instituto español de Oceanografia". Work was carried on intensively in the Straits of Gibraltar and neighbouring areas, in the region between Malaga and the Chafarina Islands to the East and Casablanca and the mouth of the Guadiana to the west. 540 operations were carried out, having as their objective the elucidation of the complicated phenomena of the Straits and the biology of the tunny.

1925, 1926 and 1927. In accordance with the decisions of the International Council for the Exploration of the Sea a number of cruises were made to the north of Spain by the gunboats "Marqués de la Victoria" and "Eduardo Dato" and the destroyer "Proserpina". The plan of the work and the results obtained appear in the "Rapport Atlantique" for 1925 and 1926. We therefore do not think it necessary to deal with them in this article.

Having, with the brevity required by the scope of this article, dealt with the campaigns which the "Instituto español de Oceanografia" has conducted in the Atlantic, we must now proceed to enquire into the principal results obtained in these campaigns, dealing first with the oceanographical characteristics of the Straits of Gibraltar and of the North and North-West of Spain, and then dealing with the biological work which has been done.

Oceanographical Characteristics of the Straits of Gibraltar.

Although in the campaign undertaken by the "Instituto español de Oceanografia" in 1914 and 1915 from Cadiz to the Balearic Isles, a certain number of isolated data were obtained in the Straits of Gibraltar, and while in 1909 and 1910 the laboratory of the Balearic Isles made

some interesting studies of the Mediterranean Riff, especially in the region of Melilla, the systematic examination of the Straits of Gibraltar only began with the "Giralda" expedition in 1920—21 or perhaps rather with that of the "Averroes" in 1922 in Algeciras bay; an examination which was continued in the following year. It is to this latter campaign carried out by the "Almirante Lobo" that we owe our present knowledge.

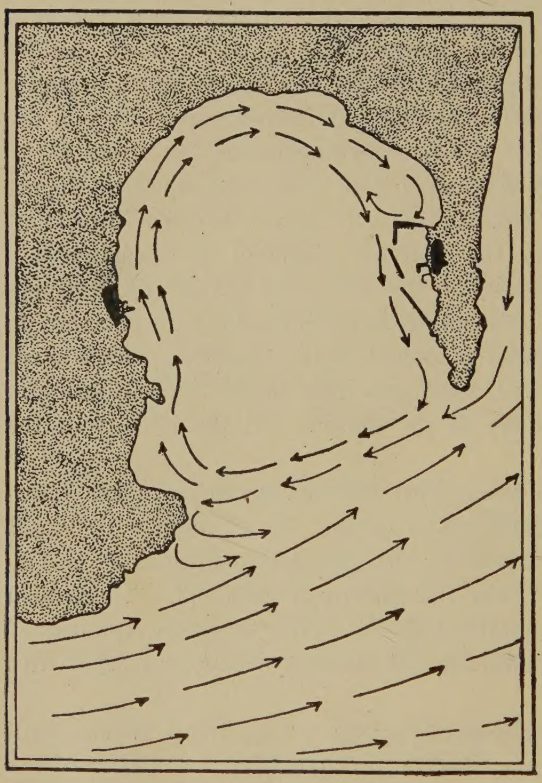

Fig. 1. Surface currents in the bight of Algeciras.

The Algeciras campaign of 1922 was very complete from the oceanographical point of view including as it did the study of the sea-bottom and of the physical and chemical characteristics of the water.

The conformation of the sea-bottom at Algeciras indicates the existence of a superficial current which proceeds from the Mediterranean and passes by Europa Point to describe a circle within the bay, the waters circulating in a clockwise direction (Fig. 1). This current gives to Algeciras Bay a well marked Mediterranean character which is clearly demonstrated by examination of the salinity of the water.

The lithological map of Algeciras Bay also shows that there are at its centre places, down to a depth of 376 metres, completely void of sediment, which would appear to indicate the existence of deep currents of considerable intensity.

An examination of the surface temperatures in Algeciras Bay shows them to be very similar to those of the Straits of Gibraltar, the waters being colder, not only than those of the Mediterranean but also than those of the neighbouring Atlantic. In the temperatures of the deeper

waters the same characteristics are noted but more especially in the soundings nearer the surface.

These curious facts lead us to imagine the possibility of an upward movement of the deeper waters, the only possible explanation of the low temperatures of the upper layers; a continuous series of observations carried out in the centre of the bay during a period of twenty-four hours clearly showed this to be the case.

The results of the twenty-four hour observations show that the changes of temperature were much less intense at the surface than at even a slight depth, there being a very definite periodicity in the thermic variations which coincides with abrupt changes in salinity, the arrival of cold water corresponding with the arrival of denser water.

The interpretation of the phenomenon observed seems to be clear. It appears to be due to periodical "injections", which, coming from the bottom, arrive to a greater or less extent at the surface. These "injections" have a Mediterranean character and the extent to which they ascend towards the surface depends on the configuration of the sea-bottom as they more nearly attain to the surface at those points where the depth is least. As the period of these injections does not correspond with the Atlantic tide we have assumed that it owes its origin to a deep Mediterranean tide regulated by astral influence.

Although the existence of deep tides was already known, thanks to the work of O. Pettersson and other scientists of Sweden, Norway, Denmark, etc., no one had hitherto observed their presence in the region about the Straits of Gibraltar, where as we see, they play so important a part that without them it is impossible to find the true explanation of the dynamic phenomena.

The course of the surface temperatures of the Straits of Gibraltar, studied in the hydrographical expeditions of the "Almirante Lobo" in 1923, showed the existence of a marked cooling of the surface waters and indeed of the deep waters also. This cooling has characteristics similar to those observed at Algeciras, and this fact led us at once to presume that there occurs also in the open Straits an upward movement of the deep, cold, salty water proceeding from the Mediterranean.

In order not to extend this article beyond due limits, and in view of the fact that the explanation which we offer of the complicated dynamics of the Straits was published in the last "Rapport Atlantique"[1])

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[1]) Rafael de Buen: "Résultats des investigations espagnoles dans le Détroit de Gibraltar". Conseil International pour l'Exploration de la Mer. Rapports et Procès-Verbaux des Réunions. Vol. XLIV.

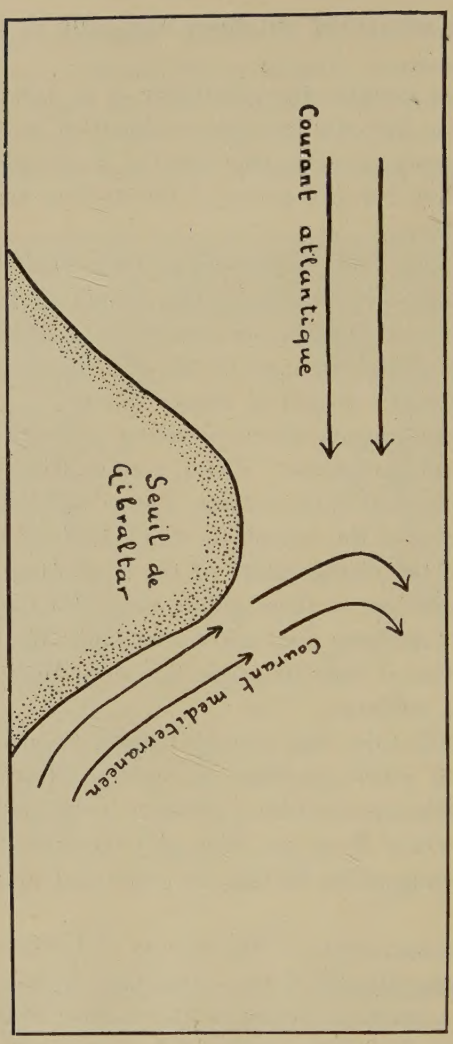

Fig. 2. Surface and bottom currents in the straits of Gibraltar.

we will confine ourselves to giving the main conclusions at which we have arrived. These may be reduced to four, as follows:—

1) Similarly to what has been observed at Algeciras, there exist in the Straits of Gibraltar, undulatory movements in deep water which bring near to or withdraw from the surface the Mediterranean waters of the lower layers. These movements originate in the Mediterranean and must move towards the Atlantic in an East to West direction.

The deep wave-movement is modified by the configuration of the sea-bottom, and when in its course it meets the abrupt slope in the Straits the horizontal undulatory movement is transformed into an inclined current in the direction of the surface, driving towards it the bottom waters.

2) The Mediterranean bottom waters moving towards the surface in the Straits of Gibraltar encounter the violent Atlantic surface current, which, by reason of its intensity, turns them back on their path and forces them again Eastwards, impeding their entry into the Atlantic (Fig. 2).

As a result of this it may be seen in all the series of observations made during the campaign of the "Almirante Lobo", as also in the maps which are based on the observations made during the campaigns of the "Dana" and the "Thor", that at no time do the Mediterranean waters penetrate to the Atlantic. This must not, however, be accepted as an established fact until further investigations have been carried out,

having as their object to discover whether at any time, at the moment when the bottom waters approach most nearly to the surface, some quantity of Mediterranean water does not find its way into the Atlantic.

3) The Mediterranean influence in the Atlantic was found in all the observations to be nil. It is therefore necessary to seek some other explanation of the existence of warm, dense water to the S.W. of Ireland, in which some experts have considered that they could see a markedly Mediterranean character.

4) The Atlantic water which enters the Mediterranean in the surface current rapidly changes its character, increasing in density and rising in temperature. This abrupt change is not due solely to the effect of evaporation, as previous experts who have examined the matter have supposed, but principally to a rapid mixing with Mediterranean water from the bottom (the ascending current to which we have already referred) and at the surface.

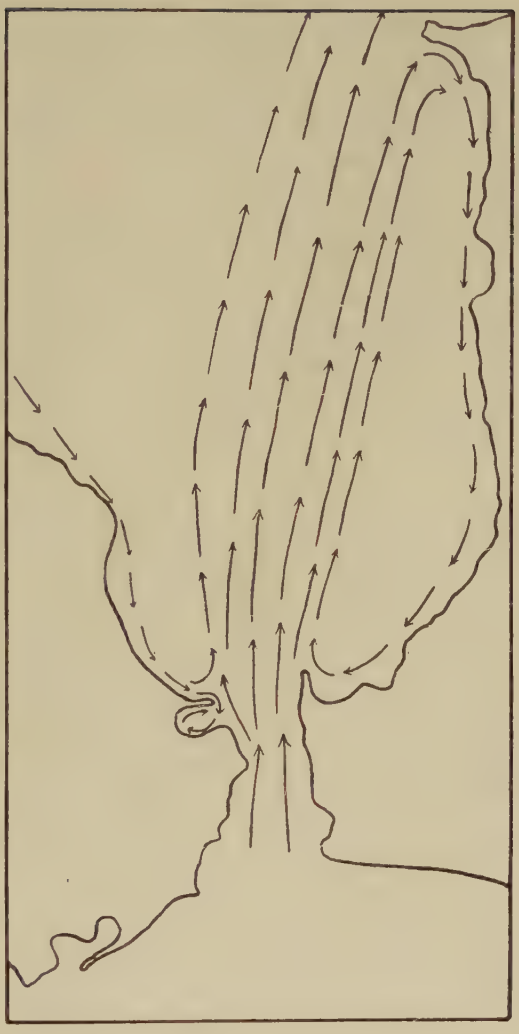

Fig. 3. Surface currents in the straits of Gibraltar ("Almirante Lobo").

There are as a matter of fact two coastal currents in the Mediterranean (Fig. 3); one which follows the Spanish coasts coming from the East and penetrating into Algeciras Bay, and the other which arrives along the coasts of Morocco.

The first has been known for some time, and it must form part of

the general movement which, according to various authors, forms a complete circuit in the Western Mediterranean.

The current of North Morocco was discovered during the campaign of the "Almirante Lobo". It is due to the clash between the surface water of the Mediterranean — which is turned aside to the right as a consequence of the rotation of the earth — against the salient of Cape Tres Forcas, where a branch current in the opposite direction is produced, which turns back again to the Straits to mix its waters there with those which penetrate from the Ocean.

This rapid mixing of Atlantic and Mediterranean waters explains to us the abrupt rise in temperature and increase of salinity which we find at the surface as, moving eastwards from the Ocean, we enter the Mediterranean.

Research on the Coasts of Galicia and in the Cantabrian Sea.

Professor Odón de Buen has published a note[1]) in which are shown the results obtained during the campaign carried out in 1916 off the Galician estuaries. There he shows that a very definite southern influence is at work from the Miño river to Cape Finisterre, while further to the North northern characteristics prevail with colder and less dense water.

The surface temperatures in the shallow estuaries vary between a maximum of 22.5° (on the 17th July) and a minimum of 15.8° (on the 14th June) the lowest in the interior of the Vigo estuary being normally above 16°. As a contrast, the normal in the open sea was in general considerably lower, with temperatures below those which are indicated for that part of the Atlantic in the ordinary charts showing thermic distribution.

The salinity of the surface waters in the shallow estuaries had in July and August a mean value of 35.24 $^0/_{00}$, increasing from the 10th July to the 31st August, which period may be divided into two parts: the first in which the quantity of salt varied from 35 to 35.30 $^0/_{00}$, and the second when it varied from 35.30 to 35.60 $^0/_{00}$.

At 5 metres depth the mean salinity value was 35.40 $^0/_{00}$; at 10 metres, 35.47 $^0/_{00}$; at 25 metres, 35.53 $^0/_{00}$, and at 50 metres 35.55 $^0/_{00}$.

Oxygen gave a mean of 6.28 cc. per thousand; the highest noted being 8.99 cc. per thousand at a depth of 5 metres, and the lowest 2.32 cc. at 25 metres.

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[1]) Odón de Buen: "Campaña del 'Hernan Cortés' este verano". Boletin de Pescas. September, 1916.

Professor Antonio Ipiens published in 1919[1]) the methods employed in the chemical investigations carried out in 1916, 1917 and 1918. The results obtained in the first year are similar to those published by Professor Odón de Buen, to which we have already referred. In 1917 the salinity records show uniformity from the surface down to 5 metres; in the lower layers an almost constant though very slight increase occurs, and only very rarely does a minimum occur, intercalated between denser waters.

The mean value of dissolved oxygen during the investigations carried out in 1917 were: 6.075 cc. per litre at the surface, 5.820 at a depth of 5 metres, 5.422 at 10 metres, and 4.357 at 25 metres.

The campaign of 1918 afforded greater interest in that, while in the two previous years the area explored was confined to the waters between the Miño and Cape Finisterre, in 1918 the investigations extended from Vigo to Santander.

During the cruise from Santander to Aviles the salinity at the surface increased from 35.48 $^0/_{00}$ at the former place to 35.57 $^0/_{00}$ at San Vincente de la Barquera, diminishing again to 35.40 $^0/_{00}$ in the vicinity of Rivadesella and at Aviles. Between Aviles and La Coruña, the salinity, which at the first-named place was 35.40 $^0/_{00}$, increased gradually until the latitude of Luarca where its value was 35.57 $^0/_{00}$, and it remained constant from that point to Estaca de Vares, and from there it steadily increased until it attained its maximum value of 35.62 $^0/_{00}$ between Cape Ortegal and La Coruña. Salt concentration was also found to increase from La Coruña to Vigo, at first slowly up to Cape Toriñana (35.64 $^0/_{00}$) and then, after Cape Finisterre was doubled, at a greater rate until its value reached 35.70 $^0/_{00}$.

These facts are in agreement with the ideas of Professor Odón de Buen, according to whom the waters to the south of Cape Finisterre have a southern character, while to the north, following the Spanish coasts, the northern characteristics are dominant.

The mean values of dissolved oxygen in the water, taken in the summer of 1918, were 4.682 cc. per litre at the surface, 4.714 at 5 metres, and 3.840 at 25 metres depth.

Independently of the work carried out during these campaigns, the accounts of which still await publication, regular observations were carried out on the thermic conditions in the Vigo estuary during 1918[2])

[1]) Antonio Ipiens: "Trabajos realizados en los años 1916, 1917 y 1918 por las costas de Galicia, Asturias y Santander. Investigaciones Químicas" Memorias del Instituto español de Oceanografia. Tomo II, Memoria I, 1919.

[2]) Miguel Perez y Gutierrez: "Observaciones oceanográficas en Vigo (segundo semestre de 1918)". Boletin de Pescas 1919, page 151.

and 1919[1]). These observations provided material for the graphs accompanying the present article (Figs. 4, 5, 6 and 7), which, better than any description, give an idea of the thermic conditions in that region, which are of particular interest in view of the relations which may exist between them and the migrations of sardines and other fish, which are of great financial importance to Galicia. We do not think it necessary to concern ourselves here with the investigations carried out in 1925 and 1926, since they are already dealt with in the "Rapport Atlantique" for 1925 and 1926 published by my colleague Dr. Le Danois.

Biological Investigations.

Fisheries are of very great importance to Spain, forming as they do a source of wealth second only to Agriculture. In spite of this fact very little attention has been paid to biological investigation until recent years, when, thanks to the creation of the "Instituto español de Oceanografia" and more recently of the "Dirección General de Pesca", due attention has been paid to this important branch of science.

There do not yet exist in Spain fishery statistics in any way complete nor of any adequate degree of accuracy. But we may expect that this deficiency will be made good in the future, in view of the fact that the statistical services of the "Dirección General de Pesca" have been organised, and that inspectors have been appointed, whose interest it will no doubt be, living as they do on the coast and having high qualifications, to obtain the exact data which are necessary for a complete statistical survey.

In 1920 delegates of the Dirección de Pesca visited the coasts of Spain with the object of forming an estimate of the fishery resources of the country. To these delegates we owe the greater part of the statistics published: in which we find as an estimate of the total catch of the sea fisheries of Spain, including Morocco and the Canaries, a total of 401,677,680 kilogrammes, that is to say approximately 400,000 tons. Of this total the Atlantic coasts of the Peninsula account for 231,000 tons, the Mediterranean, 68,000 tons, while the remainder, some 100,000 tons, come from the Canaries, the coasts of Morocco and the Canario-African fisheries.

In 1920 there were in Spain 30,604 vessels employed in the fisheries with a total tonnage of 117,840 tons. Of these vessels, 1549 were motor boats with a total tonnage of 35,582 tons.

[1]) Miguel Perez y Gutierrez: "Observaciones oceanográficas en la Rio de Vigo (Mayo-Junio 1919)". Boletin de Pescas 1920, page 261.

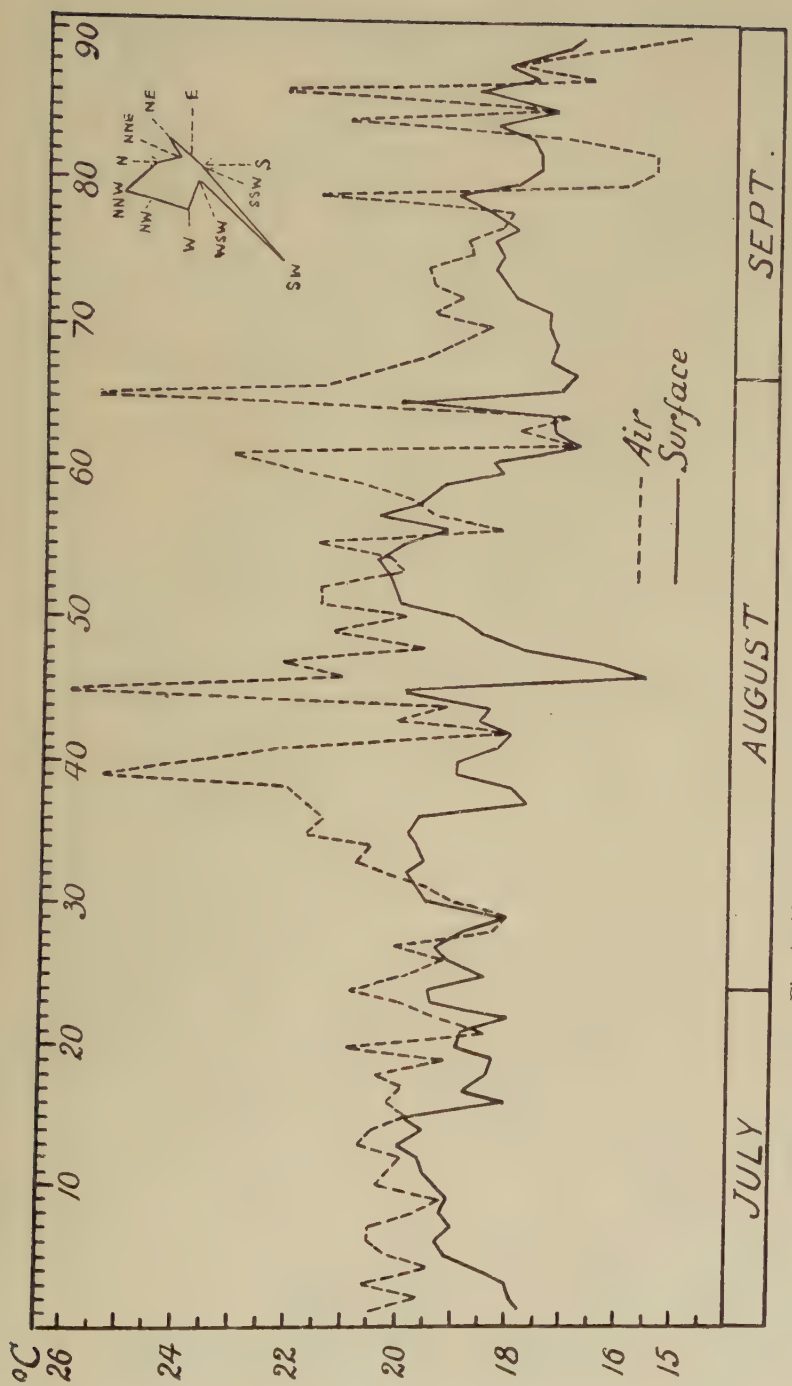

Fig. 4. Air and surface temperature in Vigo estuary, 1918.

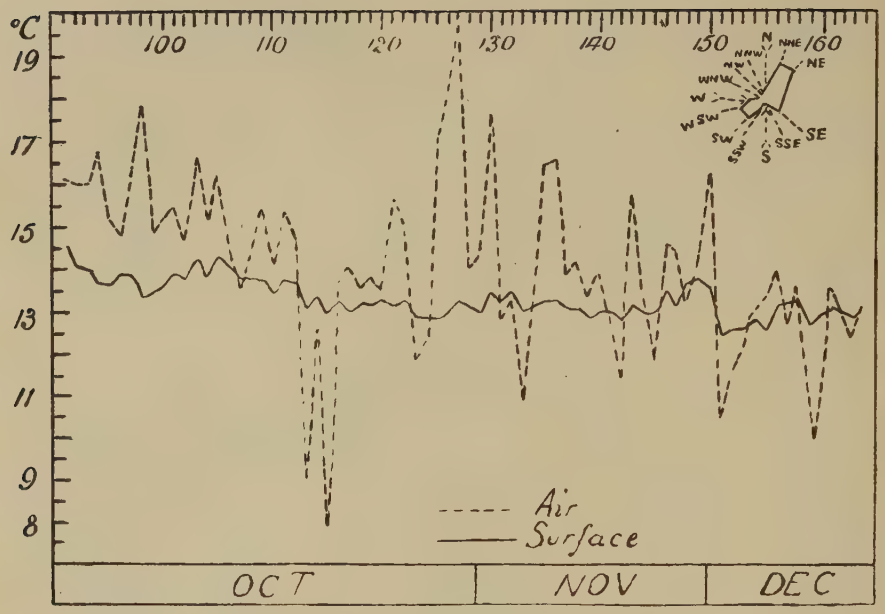

Fig. 5. Air and surface temperature in Vigo estuary, 1918.

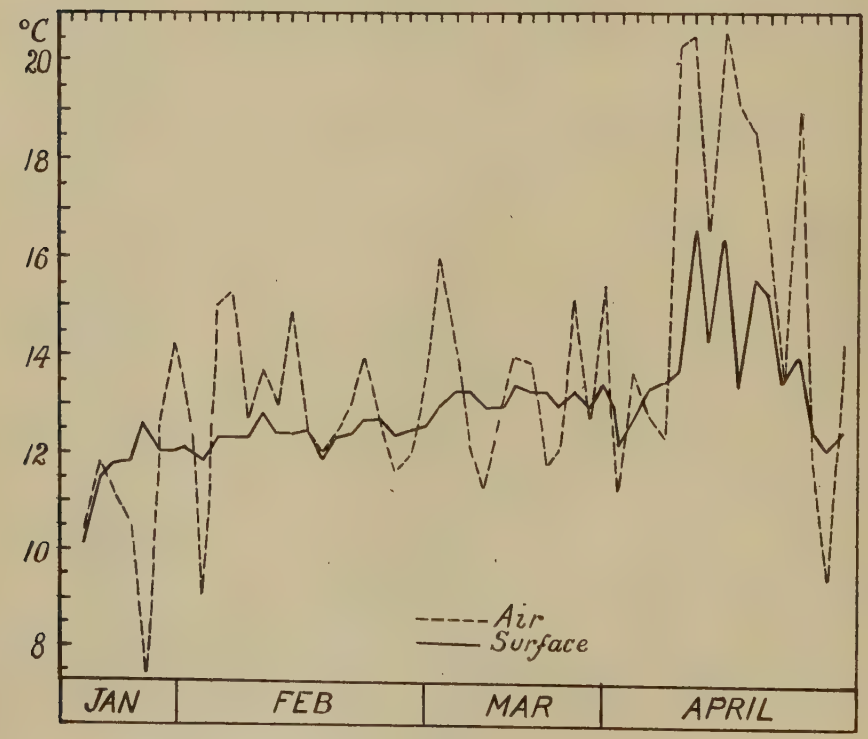

Fig. 6. Air and surface temperature in Vigo estuary, 1919.

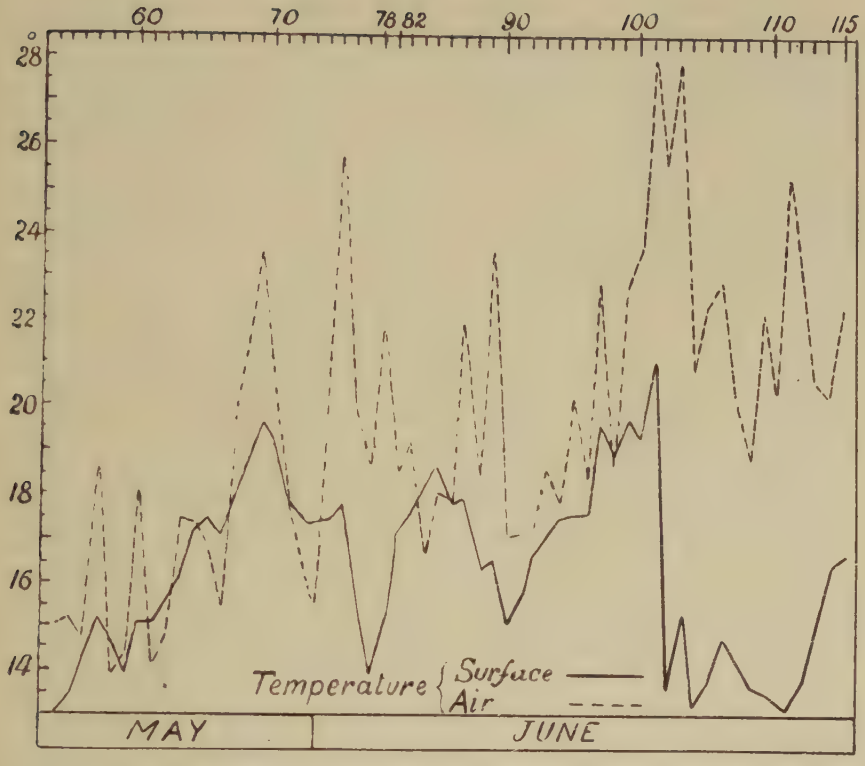

Fig. 7. Air and surface temperature in Vigo estuary, 1919.

In Spain there are quite a large number of food fishes, among which mention must obviously be made of the Sardine (*Clupea pilchardus* Walb.) the Tunny and other Scombridæ, the Anchovy (*Engraulis*), the Sprat (*Clupea sprattus*), the Hake (*Merlucius*) among many others.

We must in this article confine our attention almost exclusively to the biology of the Sardine and the Tunny, the two species which have up to the present attracted the special attention of the Instituto español de Oceanografia, firstly on account of their economic importance, and secondly because they are migratory species of which it is necessary that we should know all about the movements if we are to intensify the fishing for them.

The sardine is the fish of greatest importance in all the coasts of Spain. The statistics collected in 1920 give for this fishery in the Mediterranean and for the Atlantic along the coasts of the Spanish peninsula a total of 118,000 tons, made up as follows:—

Atlantic.	
Gulf of Gascony and Cantabria	15,242 tons
Galicia	41,000 —
South Atlantic (Bay of Spain)	36,110 —
	92,352 tons
Mediterranean.	
Southern Zone	15,556 tons
Levant	3,000 —
Catalonia	6,632 —
	25,188 tons

These statistics show us that the sardine is of more especial importance in the Atlantic, where the fishery is about four times as great as in the Mediterranean.

The tunny is the objective of a very important fishery off the Spanish coasts from the ports in the Bay of Spain, where in 1920 a dozen tunny nets were used, taking 777,130 fish of a total weight of 6,317,187 kilogrammes. In this figure are included a number of smaller Scombridae but, while the actual number of fish taken was fairly high, their weight is very small as compared with the total mentioned above.

The tunny is also fished in the Atlantic to the North of Spain, principally in the Gulf of Gascony, and, though its economic importance is small compared with that of the northern bonito (*Germo allalonga*) the total fishery for Scombridae in Spain, including the Mediterranean and the region of the Canaries, amounted in 1920 to the high figure of 14,000 tons.

The Sardine.

The biological investigations in connection with the sardine began with the first campaign carried out in the Atlantic in 1916 by the Instituto español de Oceanografía with the "Hernan Cortés". Since that time a considerable amount of work has been carried out which enables us to bring together a large number of data and to arrive at important conclusions which will be tested and completed by subsequent investigations. The results obtained up to the present appear in various publications of the Instituto español de Oceanografía to which we must refer in the brief review which we now propose to give.

Writing of the results of the "Hernan Cortés" campaign in the Galician estuaries in the summer of 1916, Professor Odón de Buen[1])

[1]) Odón de Buen. "Campaña del 'Hernan Cortés' este verano". Boletin de Pescas. September 1916.

tells us that, as the summer was dry and warm, keeping the temperature of the water above the normal, the circumstances at the time when the investigations were made were favourable to the life of migratory fish which require temperate water. As a result there was an abundance of sardines, but, on the other hand, a scarcity of anchovies (*Engraulis*) and sprats (*Clupea sprattus*).

The majority of the sardines taken in the summer of 1916, were small and sexually immature, while the rest, the smaller proportion, were two, three and even four years old. Not a single specimen examined possessed mature reproductive organs. Moreover, in the numerous hauls of surface and deep plankton made during the expeditions, it was impossible to obtain a single sardine egg or larva.

In 1919 Dr. Fernando de Buen published a note[1]) on the biology of the Vigo sardine as the result of observations made in July, August and September, 1918. This note merits special attention in this article wherein we will point to certain conclusions of considerable interest which were reached.

Although the work refers mainly to Vigo, the author has made comparisons with the characteristics of the sardines in other parts of Spain, so that the work has greater general importance than might be assumed from the title under which it is published.

The sardine, as is well known, is particularly abundant in the estuaries of Galicia, on the coasts of Huelva and Cantabria, and is also found in the whole of the Mediterranean littoral of Spain.

Fernando de Buen, in comparing the vertebrae of the Vigo sardine with those of sardines taken on the coasts of Catalonia (Mediterranean) observed certain differences which would appear to justify the classification of these fish in two different races. On the other hand, in the examination of the vertebrae of sardines taken in various places in the Spanish Mediterranean, he observed that the differences are not essential, and that all these fish are embraced in the same morphological type.

The young sardine is called the "parrocha" in Vigo, where the smallest specimens measured were more than 100 millimetres in length. When the "parrocha" exceeds 150 mm. in total length it is called a sardine.

The "parrocha" appears twice in the year on the Vigo coasts, its arrival beginning on the one occasion in autumn and on the other, in spring. The summer "parrocha" must come from the spring spawnings, and it is found in company with adult sardines throughout the summer.

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[1]) Fernando de Buen: "Algunos datos sobre la sardina de Vigo (*Clupea pilchardus*, Walb.) (Julio, Agosto, Septiembre, 1918)". Boletin de Pescas, 1919, p. 45.

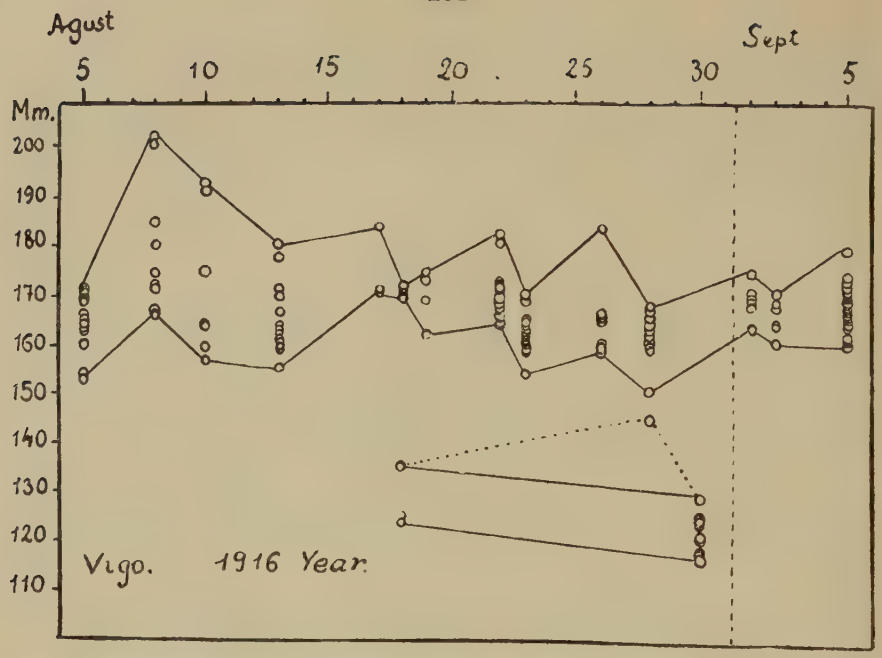

Fig. 8. Diagram showing total lengths of sardines from Vigo in Aug. and Sept. 1916. (F. de Buen).

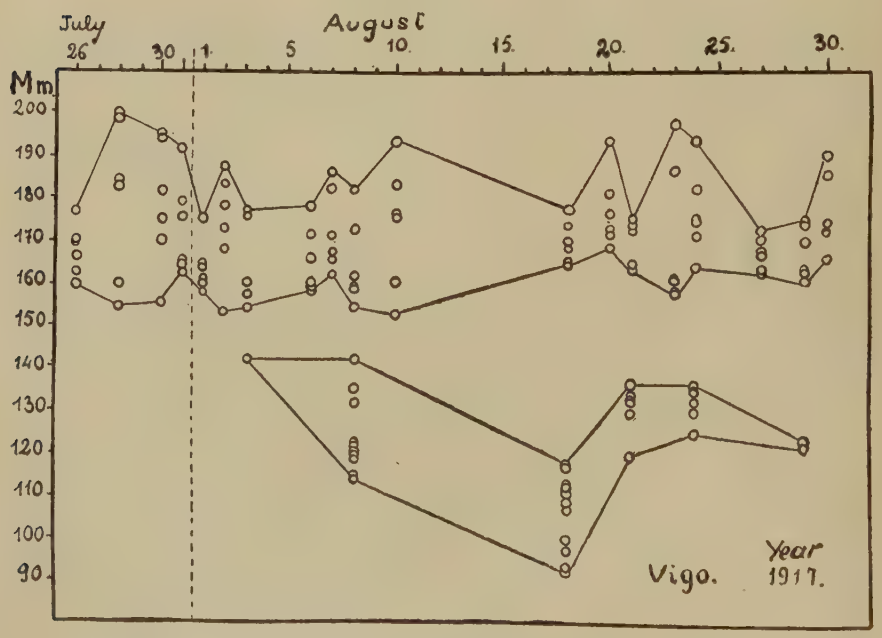

Fig. 9. Diagram showing total lengths of sardines from Vigo in July and Aug. 1917. (F. de Buen).

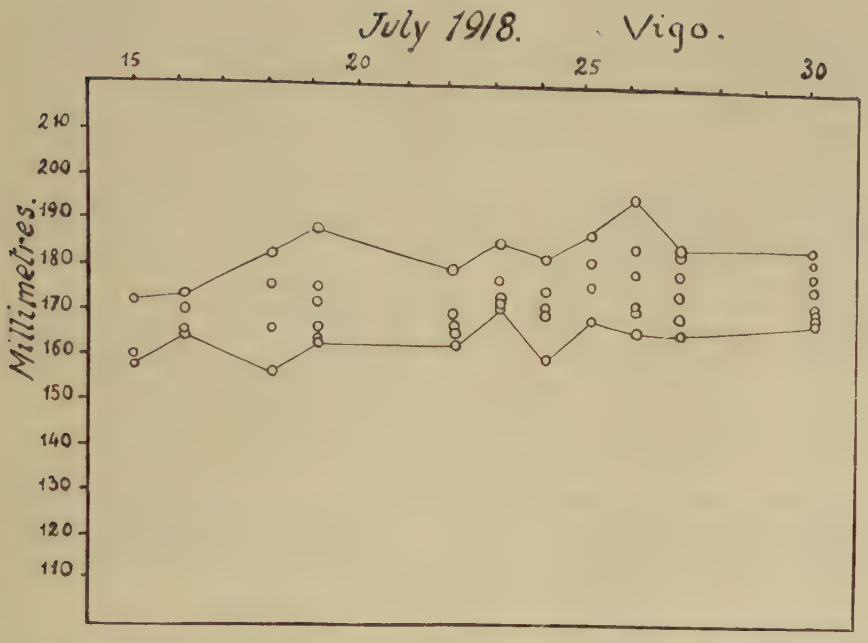

Fig. 10. Diagram showing total lengths of sardines from Vigo in July 1918. (F. de Buen).

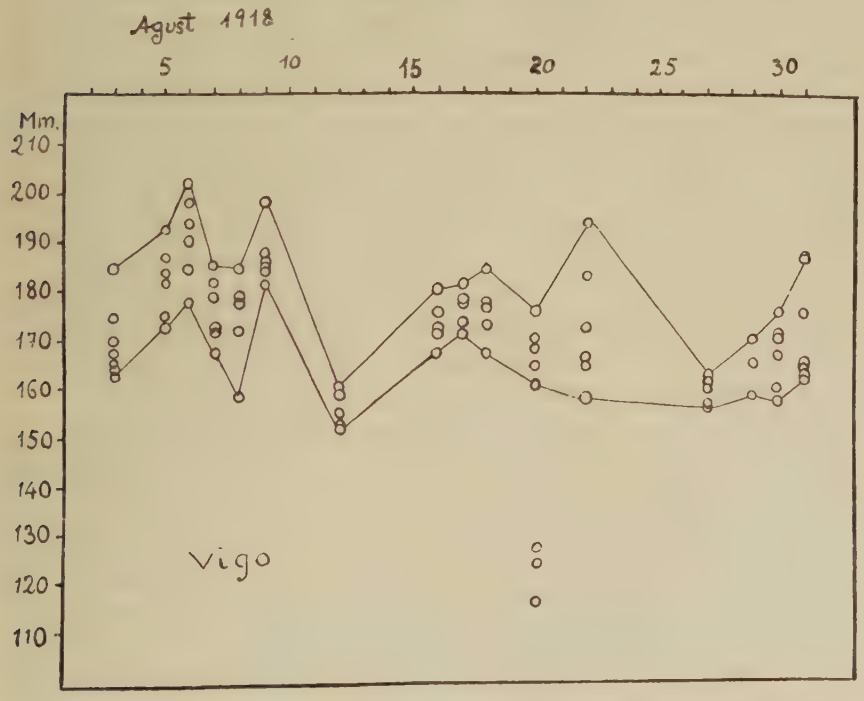

Fig. 11. Diagram showing total lengths of sardines from Vigo in Aug. 1918. (F. de Buen).

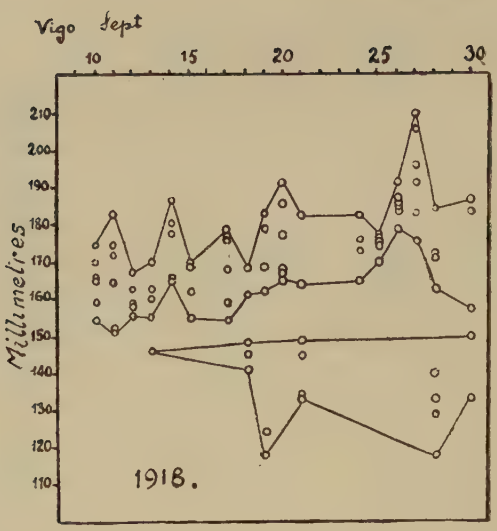

Fig. 12. Diagram showing total lengths of sardines from Vigo in Sept. 1918.

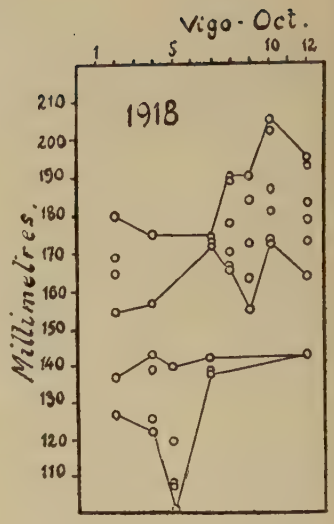

Fig. 13. Diagram showing total lengths of sardines from Vigo in Oct. 1918.

(F. de Buen).

The appearance of the winter "parrocha" is less constant, as is shown by the fact that in the early months of 1916 it was caught on very few occasions whereas during the same period in 1917 it was not absent from the catches on any single day.

The irregularity with which the "parrocha" is caught on the Vigo coasts must be due to the local oceanographical conditions. While these conditions approximate to those which are necessary for the permanent existence of the sardine in surface waters, they are liable to changes, occasioned by the winter fall of temperature, which occur over a more or less lengthy period and vary in intensity in different years.

The total length of the sardines examined in Vigo in 1916, during August and the beginning of September, varied between a little over 150 mm. and 202 mm. In addition, on three days some "parrochas" below 150 mm. were measured. (Fig. 8.)

In July and August 1917, the dimensions were very similar to those observed in the previous year. The "parrocha" was present during the whole month of August. (Fig. 9.)

In July 1918, the uniformity of size of the Vigo sardines was very marked (Fig. 10). This uniformity disappears in the succeeding months (Figs. 11, 12, and 13) when both large and small fish were taken, the largest of those measured having a total length of 210 mm.

Comparing the data for Vigo and Isla Cristina (August 1916) we

obtain the table given below. The 60 sardines measured at Isla Cristina (Huelva) and the 141 measured at Vigo (on the basis of total length) have been divided into groups, the number of sardines of each length group being calculated on the basis of a total of 100 fish in each case:—

Total length in millimetres	Number of Fish	
	Isla Cristina	Vigo
200—210	3	1
190—199	24	2
180—189	5	6
170—179	8	21
160—169	0	51
150—159	2	9
140—149	2	1
130—139	7	7
110—129	28	2
100—109	5	0
93— 99	16	0
	100	100

This table shows that sardines of 110 to 129 mm. and 190 to 199 mm. are abundant at Isla Cristina (Huelva), while at Vigo the group of most frequent occurrence is the 160—169 group, with smaller quantities attaining a total length up to 179 mm. We also notice the curious fact that at Isla Cristina there are no sardines of lengths between 160 and 169 mm., and similarly that neither at Vigo nor at Isla Cristina were there caught in August 1916 young sardines less than one decimetre in length.

X. Ducloux affirms the existence on the coasts of Vigo of young sardines of less than 40 mm., but F. de Buen in the course of his observations was able to find only one "parrocha" in that locality of 92 mm. (August 18th, 1917).

The examination of the relation between the length and the weight of sardines at Vigo, by Dr. F. de Buen, reveals the fact (Fig. 14) that the young fish increase in length more rapidly than in weight, the rapidity of increase in size diminishing in the adults. Sardines weighing between 30 and 60 grammes were the most abundant on the Vigo coasts at the time when the observations were made.

The increase in weight of the Isla Cristina sardines (Fig. 15) does not follow with the same regularity as was observed at Vigo. The graph shows a break at the 150 mm. length.

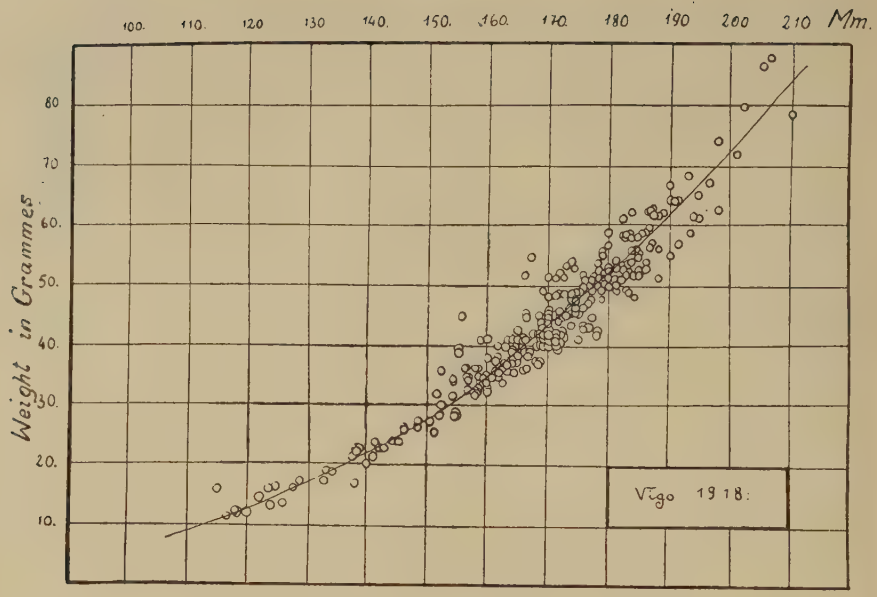

Fig. 14. Relation between length and weight in Vigo sardines

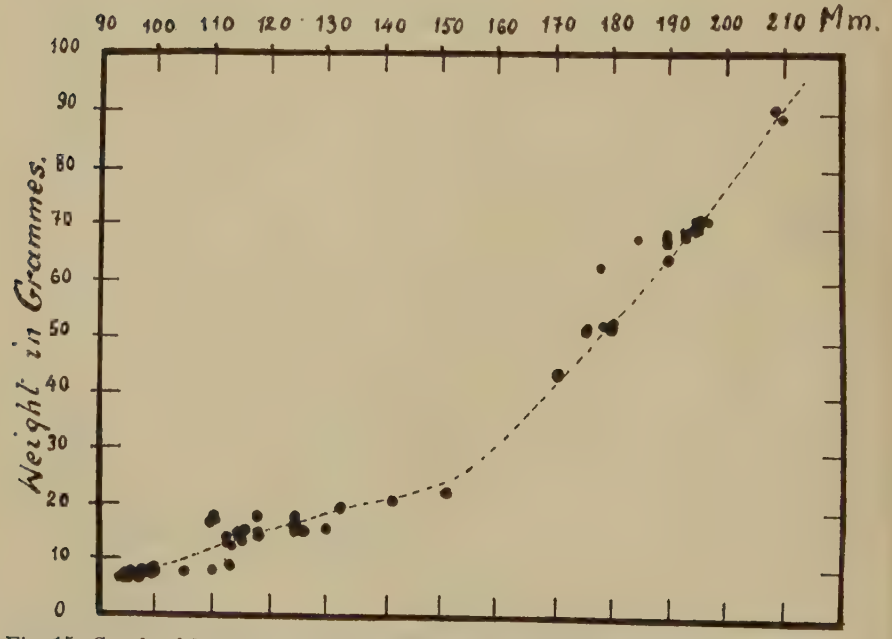

Fig. 15. Graph of length in relation to weight. Data obtained from materiel taken at Isla Cristina. (Huelva).

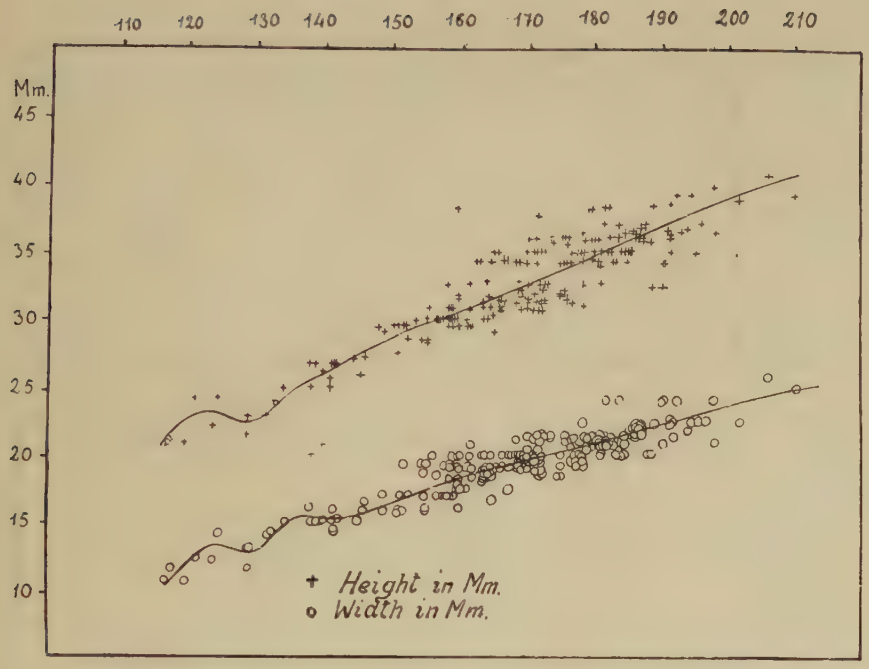

Fig. 16. Height and width, from measurement of sardines taken at Vigo (July to Oct. 1918).

The height and width increase with the length of the sardines, there being a fair degree of uniformity in the increase though the increase in height is more rapid than the increase in width (Fig. 16). At the beginning of the graph, between 110 and 140 mm. a rise appears to correspond with these data, but Dr. DE BUEN does not consider that the irregularity is normal, since if it were so it would correspond to a delay in the increase in width and height coinciding with an increase in the length of the individual.

The investigations into the biology of the sardine were continued by Dr. F. DE BUEN, and, in connection with the work of obtaining statistics of the value of the fisheries carried out in 1918 on the Basque coast, he published certain data of some interest[1]), among which the observation is particularly noteworthy that in the whole course of the investigations in connection with the sardine fishery of San Sebastian the fish was never absent in any month of the year.

[1]) FERNANDO DE BUEN: "Datos para la estadistica de pesca en las costas Vascas (1918)". Boletin de Pescas, 1920, p. 129.

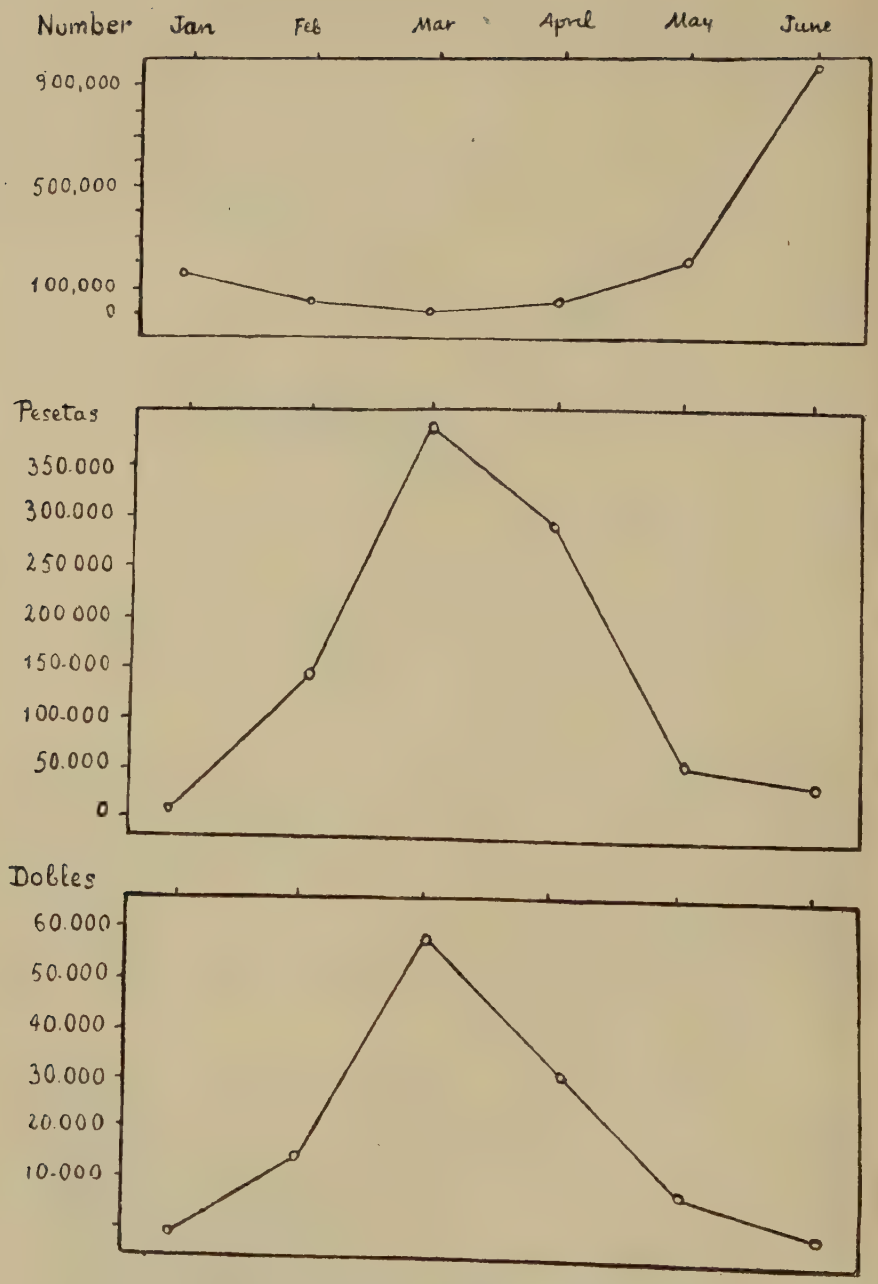

Fig. 17. Graphs of the variation of the number of sardines, quantity (in "dobles") and value (in pesetas) during the first half of 1918. San Sebastian.

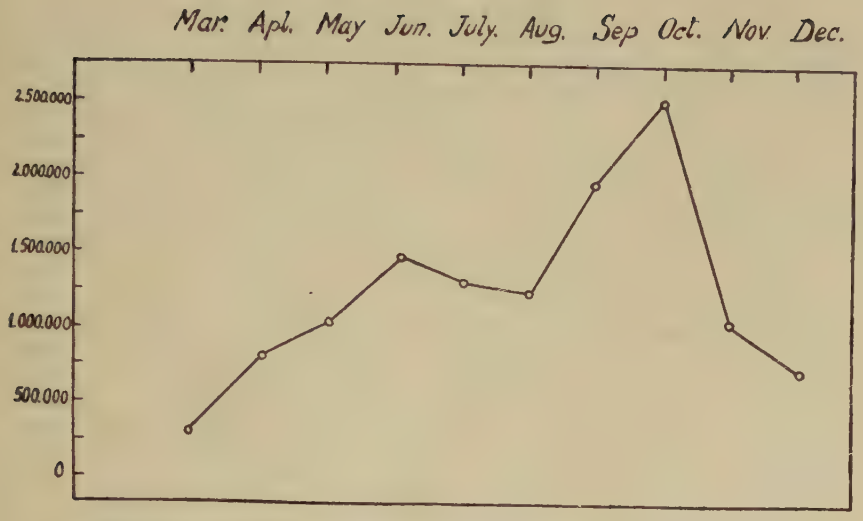

Fig. 18. Graph of the numbers of sardines taken in 1919. Isla Cristina (Huelva).

In the first six months of 1918 the point of greatest activity in the San Sebastian sardine fishery occurred in March, whereas at Motrico and Ondarroa, neighbouring villages, the maximum occurred in April.

The graphs in Figure 17 show the number of sardines, partly by number of individual fish and partly by "dobles" (the measure called "doble decalitro" (double decalitre) in San Sebastian, is equivalent to 550 sardines) and their value in the first six months of 1918 at San Sebastian. The fact is brought out that the highest point of the fishery occurred in March, as we have already pointed out.

Alvaro de Miranda, in a work on the fishery statistics of the Andalusian coast[1]), brings out the fact that the fishery with the "tarrafa" (purse seine) at Isla Cristina takes place only from March to December inclusive, while at the same time, and even in those months when the "tarrafa" is not used owing to the scarcity of sardines, a certain number of "jabegas" (shore seines) are used.

The graphs which he published on the quantities of sardines taken in 1919 (Fig. 18) at Isla Cristina (Huelva) clearly show the cessation of fishing in January and February, and the occurrence of the maximum catch in October.

In connection with the effort made in 1920 to obtain complete stat-

[1]) Alvaro de Miranda: "Notas de Estadistica de pesca en la costa andaluza". Boletin de Pescas, 1921, p. 121.

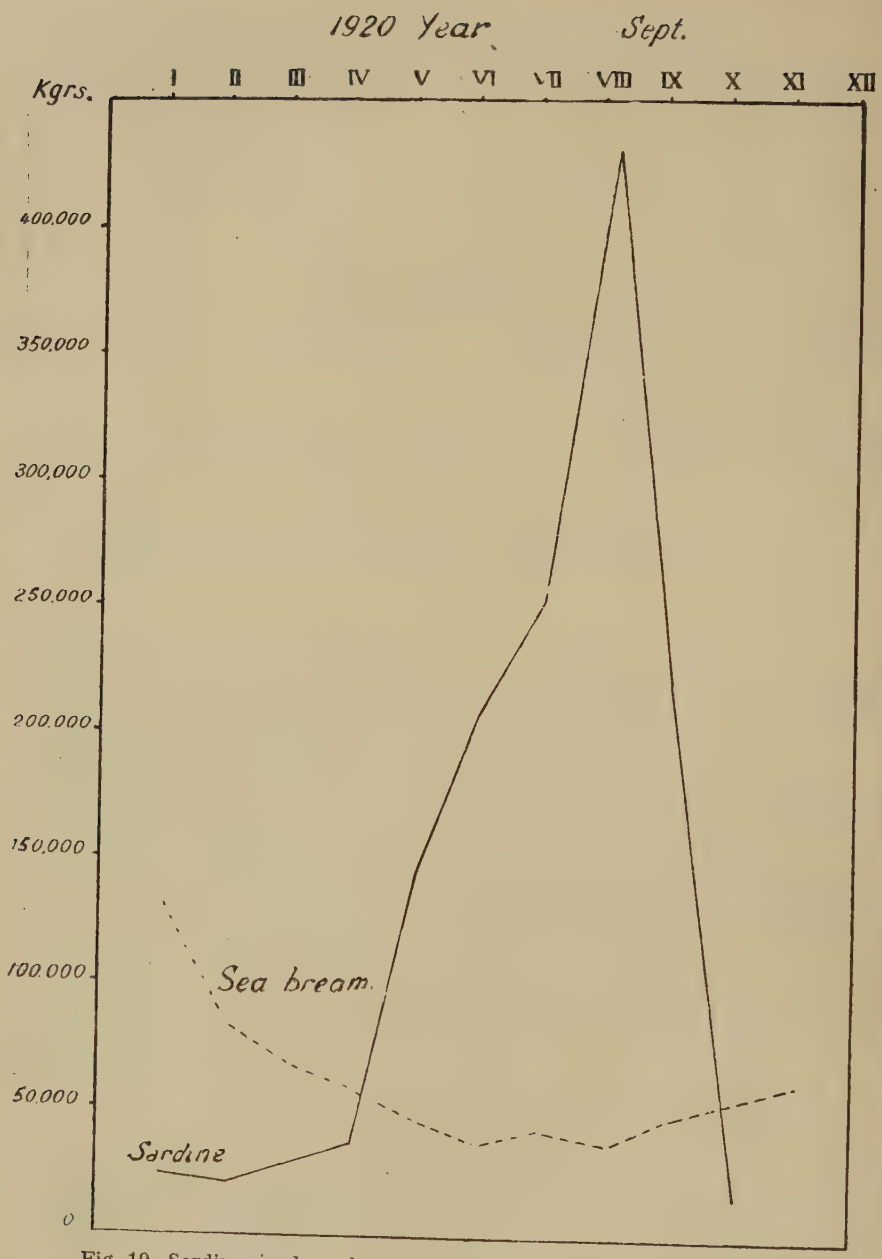

Fig. 19. Sardines and sea-bream landed on the mole at La Coruña.

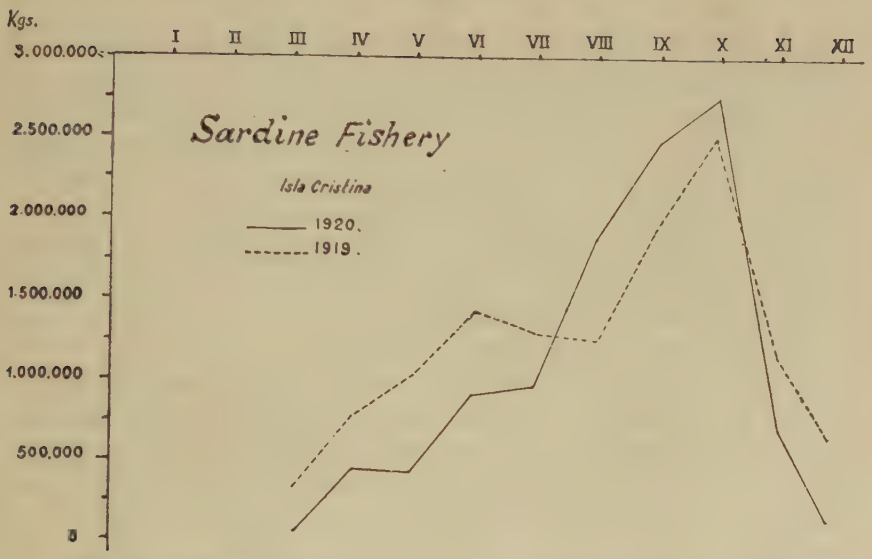

Fig. 20. Sardines sold in 1919 and 1920 in the market of Isla Cristina.

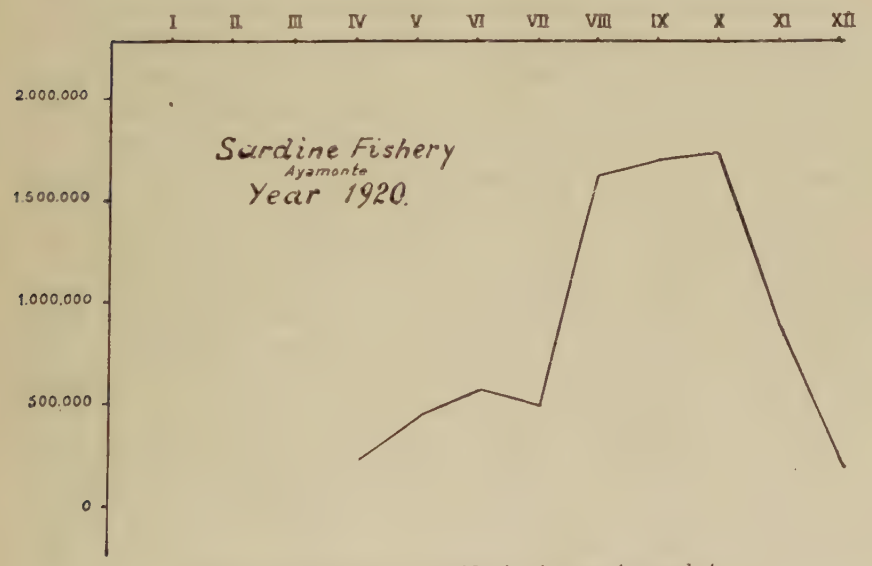

Fig. 21. Sardines sold in 1920 in Ayamonte market.

istics of the fisheries, the experts engaged in the work paid considerable attention to the study of the sardine and published biological and graphical data which we consider suitable for inclusion in this summary.

Luis Alaejos, who was engaged in preparing the statistics for the

coasts of the province of Santander[1]), points out that the highest point of the sardine fishery varies according to the locality: for Santander, Comillas and San Vincente it occurred in September; for Santoña, where considerable quantities were caught, in January; for Laredo in November; and for Suances in October. Comparing the months of most intensive fishing at the different ports, we see they are from October to January at Santoña and Laredo and from June to November in Suances, Comillas and Santander. It would appear from this that we are entitled to draw the conclusion that a migration of the sardine occurred in 1920 from the coasts of Asturias to those of Santander.

Dr. Alaejos, taking the data for previous years, shows that the period of greatest intensity in the Santander sardine fishery in 1918 occurred between April and November, the highest point reached being in September. In 1919, on the other hand, the months of most intensive fishing were February, April, May and June, with the maximum in February.

The graph of the sardine fishery at La Coruña in 1920 (Fig. 19) shows that the fish was absent in December and January, but increased sharply in numbers from April to August, reaching the maximum in the latter month and then diminishing rapidly in September and October[2]).

The data published as to the sardine on the South Atlantic coasts and the Canaries are of greater interest, and we have extracted the main conclusions drawn in the memorandum published by Dr. Fernando de Buen[3]).

Sardines of large size abound at Isla Cristina, as they do in other parts of the Atlantic coast of the Iberian Peninsula, and, just as in the Mediterranean, young sardines are also found inshore. But no evidence has yet been obtained of the occurrence on the coast of Huelva of post-larval stages or of very young sardines, of which very large quantities are, however, taken at Malaga.

The sardine appears on the Portuguese coasts at the beginning of the year, migrating later to the Straits of Gibraltar whence in full summer it invades the depths of the Bay of Spain, to be found at the end of the year opposite Cadiz.

The sardine does not leave the Gulf of Cadiz during the active period

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[1]) Luis Alaejos: "La pesca maritima en España en 1920. Provincia de Santander". Boletin de Pescas, 1922, p. 35.

[2]) Fernando Dominguez: "La pesca maritima en España en 1920. Provincias maritimas de Coruña y Ferrol". Boletin de Pescas, 1922, p. 273.

[3]) Fernando de Buen: "La pesca maritima en España en 1920. Costa Sud-Atlantica y Canarias". Boletin de Pescas. 1922, p. 341.

of its life. It disappears and returns along the shores of that Gulf at the turn of the year. It may be considered perhaps, as forming a different race, intermediate between the neighbouring Atlantic and Mediterranean races.

We may assume that, on the arrival of winter, the sardine as it disappears from the vicinity of Cadiz, must traverse the distance which separates it from Portuguese Algarve following some deep water layer. Possibly in its movement into deeper water it seeks and follows the layer of Mediterranean water which penetrates into the Ocean through the Straits of Gibraltar.

The fact that the annual cycle of the sardine in the Bay of Spain is very regular is brought out by the uniformity of the dates at which the fishery commences in the province of Huelva and the dates at which the boats cease to put to sea on account of the lack of fish. In 1919 fishing began on the 8th March, and ended on the 19th December; in 1920 the dates were the 13th March and the 17th December respectively. (Figs. 20 and 21.)

The table relating to the sardine fishery at Isla Cristina in 1919 and 1920, and at Ayamonte in 1920, indicates the regular occurrence of the maximum intensity of fishing between August and October, and a rapid dimihution in November and December. This indicates that with the arrival of winter the dispersion of the sardines takes place abruptly, as if the change in the oceanographic conditions interferred with the "communal" life of this clupeoid in the surface waters.

Month	Isla Cristina		Ayamante
	1919	1920	1920
March	310,226	67,000	—
April	790,726	467,500	210,875
May	1,084,625	458,500	424,000
June	1,426,327	931,000	550,375
July	1,229,510	960,000	458,250
August	1,240,952	1,881,000	1,582,500
September	1,967,970	2,491,000	1,646,500
October	2,501,232	2,755,500	1,689,000
November	1,141,226	703,500	868,875
December	639,476	111,000	155,250
Total Kilogrammes	12,402,260	10,826.000	7,585,625

We also possess interesting data in connection with the biological study of the sardine in the shape of a number of graphs and tables on

Months	Kilogrammes	Price in Pesetas			Value in Pesetas
		Minimum	Maximum	Mean	
January	558.600	0,83	1,00	0,91	508.326
February	63.750	0,83	1,00	0,91	58.012
March	921.500	0,67	0,71	0,69	635.835
April	2.622.000	0,27	0,29	0,28	734.160
May	159.600	0,35	0,35	0,35	55.860
June	796.100	0,50	1,37	0,94	748.334
July	1.090.980	0,50	1,02	0,76	829.152
August	2.175.310	0,55	0,94	0,75	1.631.483
September	2.115.570	0,61	1,18	0,90	1.904.013
October	1.208.360	0,43	1,03	0,73	882.103
November	4.179.535	0,67	1,14	0,91	3.802.377
December	1.820.275	0,52	0,77	0,65	1.183.179
	17.711.590				12.972.834

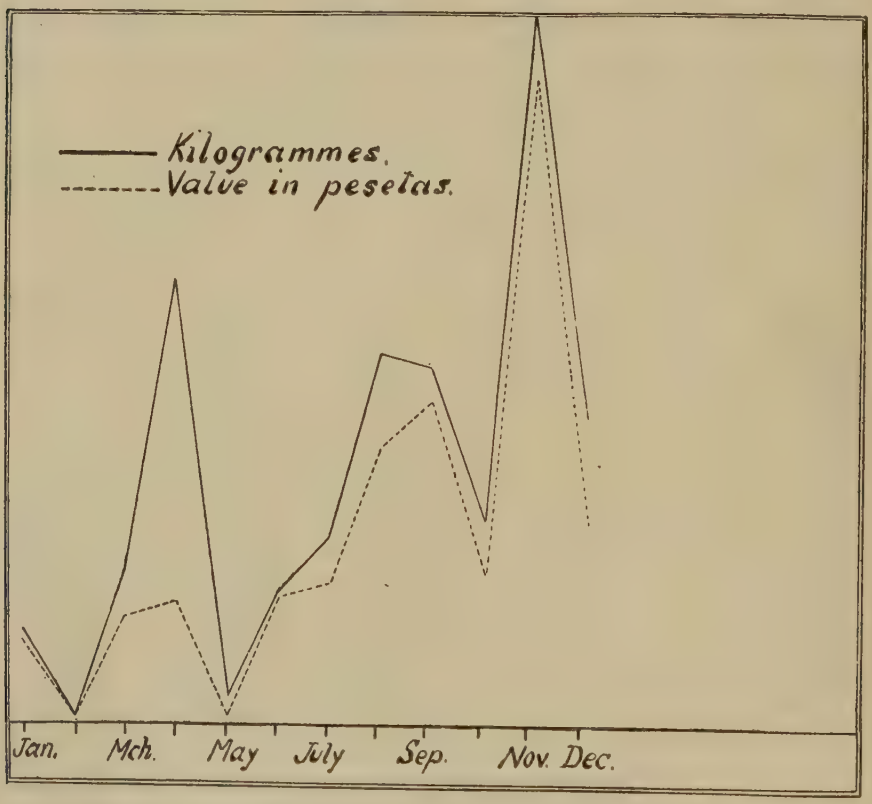

Fig. 22. Vigo. Sardines sold by auction at the Lonja de Berbés

Months	Kilogrammes	Price in Pesetas			Value in Pesetas
		Minimum	Maximum	Mean	
January	603.855	0,23	0,95	0,59	356.274
February	248.325	0,24	0,81	0,53	131.612
March	101.640	0,24	0,86	0,55	55.902
April	118.965	0,34	1,04	0,69	82.086
May	387.975	0,30	1,10	0,70	271.583
June	1.119.405	0,33	1,12	0,73	817.166
July	175.875	0,11	0,87	0,49	86.179
August	450.030	0,21	0,73	0,47	211.514
September	935.970	0,10	0,86	0,48	450.266
October	1.499.190	0,11	1,03	0,57	854.538
November	1.656.585	0,14	0,33	0,24	397.580
December	2.352.000	0,14	0,71	0,43	1.011.360
	9.649.815				4.726.060

Fig. 23. Vigo. "Parrocha" sold by auction at the Lonja de Berbés.

the sardine and "parrocha" taken at Vigo (Figs. 22 and 23) in 1920[1]), and on the sardine fishery at Gijon (Fig. 24) during the same year[2]).

The record of the dates at which the sardine fishery with "tarrafas" began at Isla Cristina (Huelva) in the years 1919 to 1926, serves as a complement to the work of Dr. F. de Buen mentioned above.

1919	1st March
1920	13th March
1921	8th March
1922	20th March
1923	10th January
1924	7th January
1925	9th January
1926	20th January

If we compare the quantities of sardines taken in the months of March, April and May at Isla Cristina in the years named we see that the fishing in every case increased from March to May, that in 1924 the March fishery produced practically nothing and that in 1926 only an extremely small number of fish were caught in the three months in question.

Although we could proceed to give a number of further data which are of undoubted interest in connection with the study of the biology of the Spanish sardine, the record would take too long, and we should probably enter too much into detail, so we must deny ourselves this record and in the present article will confine ourselves to a general outline of the knowledge which has been obtained up to the present. This outline will be based on two works recently published by Dr. Fernando de Buen[3]), and more especially on the second which appeared this year, in which we shall, therefore, find brought together and discussed the principal questions studied up to date.

Dr. Fernando de Buen points out that the sardine is typically an stenothermal fish, and that its migrations are derived from the changes in the temperature conditions of the water. He shows how the sardines

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[1]) Armando Pontes: "La pesca maritima en España en 1920. Rias bajas de Galicia." Boletin de Pescas, 1923, p. 1.

[2]) Alfonso Bolin: "La pesca maritima en España en 1920. Asturias." Boletin de Pescas, 1922, p. 113.

[3]) F. de Buen: "Estudio de la edad por las escamas en sardinas (*Clupea pilchardus*, Walb.) de Vigo." Notas y Resumenes del Instituto español de Oceanografia. Serie II. No. 8. Marzo 1925. — Notas y Resumenes del Instituto español de Oceanografia. Serie II. No. 15. Febrero, 1927.

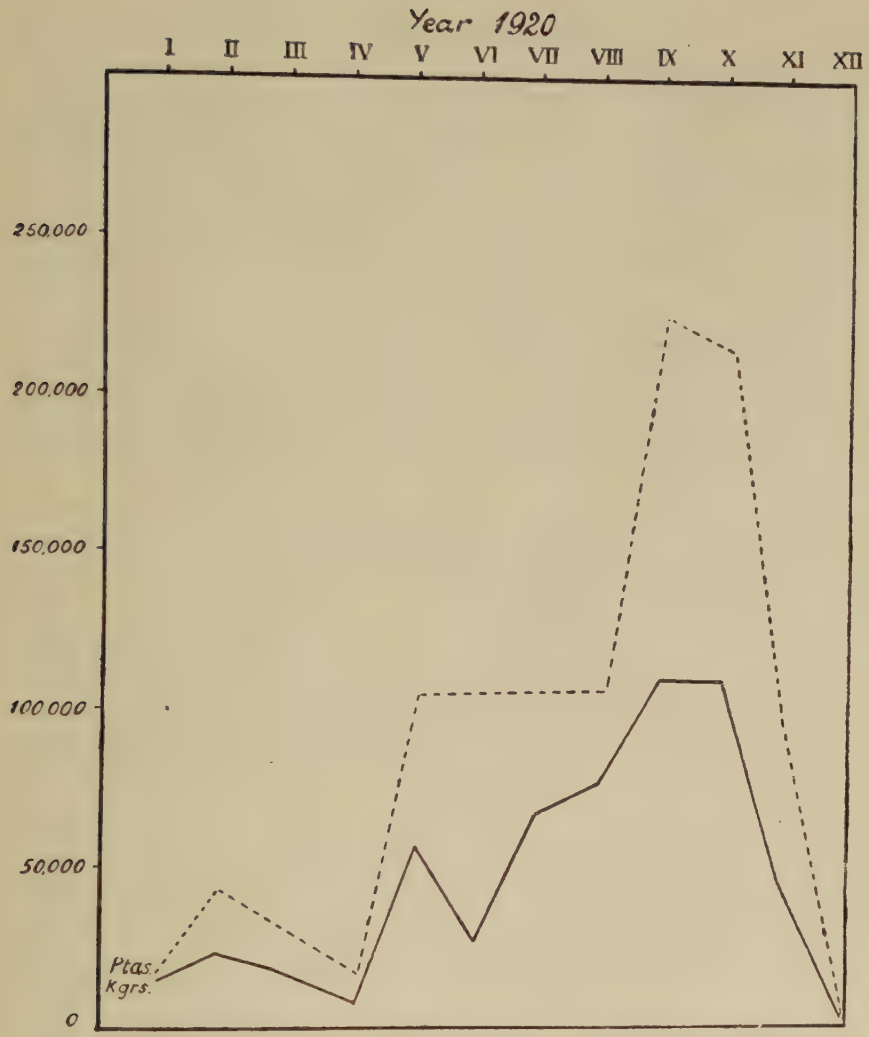

Fig. 24. Fluctuations of sardine fishery in 1920. Port of Gijon.

congregate close to the coasts in the summer in search of the high temperatures which favour the abundance of the plankton on which they feed, and thanks to which they steadily fatten and their sexual organs develop, their activity slowly relaxing with the arrival of winter and the reduction of the supply of food.

Spawning takes place in winter when the fish in full sexual maturity disperse along the isotherms in different areas according to the changes which the sea undergoes in different years. As a rule there is no spawn-

ing area at Vigo, the spawning areas being found in cold winters somewhere off the coasts of Portugal to the South of Galicia.

When the scales of the Vigo sardine are examined there appear clearly marked the narrow transparent straight lines formed during the winter, and the broader finely grooved spaces corresponding to the summer. In the determination of age from the scales, each winter line corresponds to one year, but allowance must be made by adding the period which has elapsed between the last winter and the time when the fish in question was taken. The maximum error which can be made is only one of five months, three of which may be due to the variation in the time of spawning and the other two to the variation in the time when the winter season commences. A sardine which has been born early may be five months older than one born at the end of the spawning season.

For the purpose of measuring the development of the zones which are successively formed on the scales, Dr. F. DE BUEN employs a simple method. He places a photograph of a scale, enlarged 10 diametres, over a graduated rule, and using the camera lucida, he obtains — since the size of the scale bears a direct proportion to the specimen to which it corresponds — rapid results by means of a slide rule.

In the Vigo region there is an abundance of sardines of from one to three years old, the proportions found to exist in the years in which investigations have been made being up to date as follows:—

5.0	per	100	sardines	are	1	year	old					
46.6	-	-	—	-	from	1	to	2	years	old		
37.4	-	-	—	-	—	2	-	3	—	-		
10.6	-	-	—	-	—	3	-	4	—	-		
0.4	-	-	—	-	—	4	-	5	—	-		

As regards the types of sardines to be found on the coasts of Spain Dr. F. DE BUEN acknowledges the evidence of two distinct races: one the Mediterranean, and the other the Atlantic, which latter appears unable to go beyond the Straits of Gibraltar. This investigator declares that the examination of the vertebrae makes it possible for him to distinguish the sardines of Atlantic origin from those of the Mediterranean, as we have already indicated, and his opinion has been confirmed by NAVARRO[1]), who has found in the vertebrae of the sardines of Palma de Majorca small

[1]) FRANCISCO DE P. NAVARRO: "Estudio sobre los clupéidos de Baleares-Estados jovenes de la sardina (*Clupea pilchardus* Walb.)". Notas y Resumenes del Instituto español de Oceanografia. Serie II, No. 9, 1926.

laminations similar to those of sardines from the coasts of Catalonia (Gerona).

The spawning of the sardine, as we have already pointed out, does not take place at any exactly determined date, but varies each year within certain limits, according to the conditions prevailing in the sea, and depends in particular on the sea temperature which advances or delays sexual maturity. In Galicia spawning takes place from December to March and on the Cantabrian coast (Gulf of Gascony) between November and March.

The period of and the conditions affecting spawning in the Mediterranean are better known, thanks to the regular observations which have been carried out by the laboratories of the Instituto español de Oceanografia. At Malaga observation has shown a condition of complete sexual maturity in small fish of only 133 mm. total length. We know too, that the two sexes do not reach maturity at the same time, the males emptying their testicles before the females eject the contents of their ovaries. There follows after spawning a period of active feeding, when the sardines take not only the various kinds of plankton but also the actual larvae and young of the sardine.

The observations of the Malaga laboratory show that between April and August there is hardly any indication of the sexual condition, and development proceeds slowly; from September to October the approach to sexual maturity is rapid, and between November and March spawning takes place.

The time of spawning does not at Malaga coincide with the period of maximum temperatures. Between 19 and 20° C. the fish steadily approach sexual maturity and complete maturity is reached at temperatures between 17 and 18° C., the spawning occurring at the moment when the winter fall in temperature becomes evident.

The phenomenon just described explains the variations in the spawning period in different years; in cold years sexual maturity is retarded, while its development is more rapid if in April and March the temperature of the sea is high.

For the ontogeny of the sardine Dr. F. DE BUEN proposes the following terms:—

Embryonic (*embrion*) stage, in the egg.
Yolk-sac (*vesiculada*) stage — free, with yolk-sac.
Larval (*larva*) stage — free, with the yolk-sac of the pelagic animal (within this stage the following sub-stages may appear, though not always very clearly:— Prelarval, gradual development of

the larval characteristics, Larval, properly so called, in which the complete development of the larval characteristics is reached, and Post-larval when the larval characteristics are being rapidly lost).

Metamorphosed, or pigmented (*Metamorfica o cromogena*) stage, with intense pigmentation — with which goes as a rule a diminution in size — and a complete change in mode of life.

Immature (*joven*), the final form, at any rate as regards its general aspect, before the first period of sexual maturity.

Mature (*adulta*), from the first period of sexual maturity.

In 1923 during the campaign carried out by the Instituto español de Oceanografia with the naval transport "Almirante Lobo", quantities of young sardines were taken by night, by the use of lights to attract them in Tangiers Bay. These specimens made it possible for Dr. F. de Buen to study the arrangement of the chromatophores, and to bring to a conclusion on the spot the investigations which he had made on previous specimens obtained at Malaga.

The Tangiers sardines (May 1923) measured from 36 to 51 mm. in length, specimens from 38 to 45 mm. predominating (77.8 per 100). The Malaga sardines were all between 38 and 69 mm. in length, those from 46 to 49 mm. predominating. The examination of these young sardines made it possible for Dr. F. de Buen to distinguish three groups among those belonging to the "metamorphosed" stage and one group in the "immature" stage.

Large numbers of sardines in the "metamorphosed" stage arrive on the coasts of the Mediterranean and of the Bay of Spain, and settle there from the month of March onwards, and there the development of these forms is carried on until October and the beginning of November.

The arrival of young forms at Galicia and the Cantabrian coast (Gulf of Gascony) takes place later and they are of larger size. Between 1916 and 1919, 1,056 specimens were measured, the smallest of which was as much as 92 mm. in total length.

The delay in the arrival observed on the coasts of Galicia and the Cantabrian littoral of the young Atlantic sardine is due to the fact that it goes through its "embryonic", "yolk-sac", "larval" and "metamorphosed" stages in the open sea, seeking shallower and coastal waters only when it has reached the "immature" stage and is already provided with its distinctive pigmentation. These young fish, generally less than one year old, are in Galicia, as we have already stated, called "parrocha". At Santander and San Sebastian they are caught at lengths of from

60 to 80 mm., their arrival on the Galician coast is later and they have already attained lengths of from 90 to 150 mm.

The "parrocha" is fished in Galicia in every month of the year, but with greatest intensity from May to June and from September to November, periods which do not coincide with the greater abundance of adults. In winter the "parrochas" are accompanied by *Clupea sprattus*, while the adults move further south to spawn in better conditions. These migrations southwards of the adults are not constant, and spawning takes place in some winters actively on the Galician coast.

The Tunny.

Among the publications of the Instituto español de Oceanografia there are several works on the tunny and on similar species of Scombridae, produced mainly as a result of the work carried out in 1923 with the naval transport "Almirante Lobo" in the Straits of Gibraltar and neighbouring waters, in accordance with the resolutions of the International Committee for the Scientific Exploration of the Mediterranean.

But we shall make use almost exclusively of only two of these publications in the account which we propose to give of the results obtained in the matter of the biology and commercial industry of the tunny in Spain. We must, however, make reference to a new volume which will shortly appear on the subject of the methods employed in the tunny fishery and of the various gear used for the capture of that fish in Spain. The author of the work is the Director of the Malaga laboratory, Don Alvaro de Miranda.

Among the general treatises which have been published, one deals with the biology[1]), and the other with the tunny industry in Spain[2]), the former of which must be of the greater interest to us.

Dr. F. de Buen tells us that the tunny is a typically stenothermal fish, the isotherms marking exactly the limits of its geographical distribution, and its sensitiveness to the temperature increasing at the spawning period.

In cold periods of the year the tunny is less influenced by the medium in which it lives and the isotherms embrace a wider zone, which is circumscribed and reduced considerably at the reproductive period when a higher and more constant temperature is necessary.

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[1]) Fernando de Buen: "Biologia del Atun. (*Orcynus thynnus* L)." Resultados de las campañas realizadas por acuerdos internacionales, No. 1, 1925.

[2]) Luis Bellon: "La industria del atun en Espana." Resultados de las campañas realizadas por acuerdos internacionales. No. 3, 1926.

The influence of temperature results in the geographical distribution of the tunny varying every year and at every moment of its life.

The tunny lives normally in the surface waters and if at any time it descends it is only to a few metres depth. This opinion is opposed to that held by PAVESI and supported by the observations of SANZO on the changes of colour in the tunny after its appearance at the fishing grounds.

The stomach contents of the tunny, according to observations carried out in Spain, consist of species of fish which live at very slight depth in the sea.

It is probable that SANZO's observations regarding the variations in the pigmentation of the tunny at spawning time may be interpreted in the following way. We know that before spawning the large tunny contain abundant reserves of fat, and have a brilliant and intense colour, but that once the reproductory function is concluded, they lose colour and become debilitated. The change of colour in the tunny may depend on the reproductive functions and not on migration from the surface to deeper water and vice-versa.

The tunny is fished throughout the year. During the spawning period the fishery is carried on chiefly with large nets called "almadrabas". Apart from these nets lines with hooks are also used. These are cast rapidly into the surface of the water and the voracious fish bite. No tunny are ever caught on the hooks of the bottom lines which are set at great depths along the Continental Shelf, which would certainly happen if the tunny descended to the deeper waters.

The adult tunny which lives in the western Mediterranean is quite distinct from that which inhabits the Atlantic near the Straits of Gibraltar, the cold waters of which appear to prevent the passage of that fish.

The migrations of the tunny must be caused by changes of temperature and for that reason Dr. F. DE BUEN holds that the name "thermic theory" should be given to the theory which explains the basis of migratory phenomena. It is evident that this fact does not imply that other factors do not exert a certain influence on the life of the tunny, but their action must always be secondary and it is the temperature factor which plays the important role.

As ROULE so well remarks, the fact that the tunny does not in itself maintain a constant heat, makes it necessary for it to seek what it requires in the medium in which it lives, and causes it to be extremely sensitive to outer conditions. At the spawning period the great activity to which its organism is subjected in the formation of genital products forces it to seek even higher temperatures. And since these temperatures

are only to be found within narrow limits and in fairly restricted areas, the result is characteristic large congregations of these Scombridae.

The principal spawning places are to be found near the coast, the Atlantic tunny seeking them in the Bay of Spain, principally in the waters which wash the shores of Andalucia in Spain, and of Algarve in Portugal; while the tunny of the Western Mediterranean appears, according to Roule, to congregate about the shores of Cerdena, Tunis and Sicily, and in smaller numbers to the south of the Balearic Isles.

The concentration of the tunny, which is related to the distribution of the isotherms, is followed by a rapid dispersal over a very wide area.

The tunny of any particular sea keeps strictly to its own oceanographic zone, although its fishery is subject to considerable variations according as the spawning place changes with the particular oceanographical conditions on which it depends.

In the Bay of Spain the most important period in the fishery occurs in the summer and spring, while in Catalonia (Mediterranean) the greatest abundance occurs in the autumn.

When the tunny is on the move its most important function is feeding, though it never departs from the isothermic limits which regulate its distribution, and where the sardines, mackerel etc., which form its prey abound. The stomachs of these tunny will be found at such times to be dilated with food.

The statistics as to the maturity of the sexual organs obtained during the 1923 campaign (Bay of Spain) gave the following results:—

	Males.	Females.
May, 1923.		
Not mature	100 %	100 %
June, 1923.		
Not mature	32 -	67 -
Fully mature	60 -	30 -
Spent	8 -	3 -
July, 1923 (end).		
Not mature	1 -	26 -
Fully mature	33 -	12 -
Spent	66 -	62 -
August, 1923 (beginning).		
Spent	100 -	100 -

These results show that the spawning of the tunny in 1923 in the Bay of Spain, took place in the months of June and July, and that the males arrived at sexual maturity before the females.

The spawning period in the Western Mediterranean coincides with that of the Bay of Spain. If we compare the results obtained in successive years we can see that sexual maturity is not reached exactly at the same date in each defined area, there being variations depending on the annual thermic conditions which latter facilitate or hinder the supply of adequate quantities of food and influence the conditions affecting the development of genital products.

Following the lines traced for it by the isothermic curves, there comes a time when a certain area having been reached, the tunny finds conditions suitable for spawning. On this course, which we may well describe as "nuptial", the tunny does not change its rate of progress nor its direction to chase the prey on which it feeds. Its nutritive function is of course declining at this time, but it does not disdain to seize the easy prey which it finds in its direct route.

During the time when the tunny remains in the Bay of Spain for the spawning season, i.e., April to August, the food most commonly found in the stomachs — and it is found in abundance — is the swimming crab *Polybius henslowi* Leach, and sometimes also *Scomber*, *Trachurus*, *Loligo* etc.

Advantage is taken of the arrival of large numbers of feeding tunny on the coasts to carry on a profitable fishery with "almadrabas", the quantity of tunny caught depending on the local oceanographical conditions which determine whether the zones of favourable high temperatures are near to or distant from the shore.

An examination of the results obtained during the Spanish investigations of 1923 shows that the "almadrabas" near which the water was high in temperature and low in salinity took greater catches than the others.

The occurrence, too, of fresh water carrying matter in suspension which disturbs the normal limpidity of the water, drives the tunny away from the shore and ruins the "almadrabas" fishery near the place where the waters are disturbed.

At the time when the fishing is at its greatest intensity, the capture of tunny is less frequent, but the fish do not all arrive at sexual maturity at the same time, and, while some are spawning, others are preparing to spawn, and a third group, already spent, is dispersing to seek the abundant food needed to repair its forces. All these partial migrations occur invariably within certain fixed limits of temperature.

When spawning is over the tunny are less sensitive to changes in the medium in which they live, and they disperse in the Bay of Spain, moving towards the west. This dispersal takes place at first along the

line of the coast, making a further intensive fishing with "almadrabas" possible. The specimens captured at this time are often pallid in colour less in diameter and with the swimming bladder considerably dilated.

When the spawning is over, the little fertilised eggs, which float on the surface of the Atlantic waters in the neighbourhood of the Straits of Gibraltar, are taken along by the surface currents towards the Mediterranean, where the larvae which are produced find a splendid refuge. These waters, warm, salt and rich in plankton are the centre of the circle formed by the current which from the Straits of Gibraltar runs towards Cape Tres Forcas, thence returning to the Straits following the Mediterranean coast of Northern Morocco. In this favoured area there is an extraordinary abundance of small tunny, which never, on the other hand appear in the Bay of Spain.

When autumn arrives the small tunny migrate towards the Straits of Gibraltar. They are at that time taken in an "almadraba" which exists at Ceuta and by the Tarifa fishermen using hooked lines. The small tunny which in the cold season reach the Atlantic in shoals are about 2 years old and from 5 to 6 kgs. in weight. They remain in the Bay of Spain until they are able to accompany the larger fish in their migration towards the open sea, to a region whose bounds are yet unknown to us.

On examining the tunny of the Canaries, Dr. F. de Buen[1]) found many notable differences between them and the tunny of that part of the Atlantic which borders on the Straits of Gibraltar. We see also that there are in the Canaries no such masses of tunny as invade the Bay of Spain.

The high temperature of the water of the Canaries and its greater constancy permit of the tunny living throughout the year about the Islands. Since seasonal changes are the cause of the annual cycle which we have observed in the migratory species (all the more sensitive the greater the differences in the water temperature), we must not hide from ourselves the fact that in localities where currents exist which admit of constancy in the oceanographical conditions, the tunny, like other species with similar biological characteristics, may be found all the year round. They do not, however, congregate in large numbers near the coast, where the abundance of food and the general conditions are favourable to spawning, larval development and growth, until they reach complete sexual maturity.

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[1]) Fernando de Buen: "La pesca maritima en España en 1920. Costa Sud-Atlantica y Canarias." Boletin de Pescas, 1922, p. 341.

The constancy of the oceanographical characteristics at the Canaries is, nevertheless, not such as to include seasonal thermic variations: and it is found that in the period of maximum temperatures the tunny abounds at the surface and that in the cold periods it descends to a certain depth though never leaving the upper water layers.

Dr. Luis Bellon, in the work already quoted, treats of the tunny industry. He points out that the preserving of this fish in Spain is of very ancient origin, the products of Andalucia competing even in the time of the Phoenician occupation with those of the Black Sea, the salted goods being exported to the whole of the Roman Empire.

As a matter of fact very little fresh tunny is consumed in Spain and almost the whole catch of the "almadrabas" is absorbed for canning in olive oil, for pickling or for salting and drying either in the sun or in the open air.

There are three types of factory: those which handle tunny only, functioning only when the tunny fishing is on, those which are open throughout the year, handling not only tunny but other species such as the sardine, *Trachurus*, etc., as well, and those which are only concerned with salting.

Contribution à l'étude de la Biologie du Thon Rouge (*Thunnus Thynnus* L.).

Sur la présence de Thons Rouges en Mer du Nord et dans l'Atlantique Nord-Est.

Par

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Quelques auteurs, Henri Heldt[1]) en particulier, ont déjà signalé la présence du Thon Rouge (*Thunnus Thynnus* L.) en Mer du Nord. Considéré, autrefois, comme un être exceptionnel dans cette région, sa présence s'est manifestée de plus en plus, et, depuis plusieurs années, les captures de gros Thons rouges faites par les harenguiers qui fréquentent les pêcheries de la Mer du Nord deviennent d'une telle importance qu'elles méritent d'attirer l'attention du biologiste.

Le Thon rouge ne se rencontre pas seulement en Mer du Nord, il a également été signalé dans le Skagerrak et jusqu'à l'entrée de la Baltique; sur les côtes de Norvège jusqu'au Lofoten; à l'entrée occidentale de la Manche, en Manche et en Mer d'Irlande; sur la côte Ouest des Iles Britanniques et sur les côtes d'Islande.

Un coup d'œil rétrospectif sur la bibliographie de ce poisson montrera que ce visiteur exceptionnel a été fréquemment signalé par les différents auteurs.

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[1]) Henri Heldt. Le thon commun (*Orcynus thynnus* L.) en Mer du Nord. (Notes et Mémoires de l'Off. Sc. et Techn. des Pêches Marit., No. 22. 1923). — Henri Heldt: Résumé de nos connaissances actuelles sur le Thon Rouge (*Thunnus Thynnus* L.). (Station Océanographique de Salammbô. Bulletin No. 5. 1926.)

Distribution.

Pour la clarté de l'exposition, les différents renseignements collectionnés ont été groupés par régions et sous forme de tableau indiquant:

la référence,
le lieu de capture,
la date de capture,
quelques observations sur la taille ou le poids.

I. Mer du Nord.

Auteurs	Lieux de capture	Année	Mois	Observations
Donovan, puis Yarrel, Day.	Margate, entrée de la Tamise	1801	?	Trois exemplaires vendus à Billingsgate.
Gordon, puis Yarrel, Day	Moray Firth	1850	Juil.	abondants, taille jusqu'à 3 mètres.
do. do. do.	Au large de Craithie	1850	?	1 m 77 de circonférence, 2 m 74 de long. Conservé à Marischal Collège. Aberdeen.
Day, après Gordon.	Inverness	1850	..	1 m 52 de long.
Yarrell.	Au large de Chesil Beach.	1850	Juil.	2 m 43 de long.
Hogg, puis Day	Tees Bay, près Hartlepool.	1853	Sept.	Poids 217 Kgs.
Day.	Firth of Forth.	1868	Nov.	Un. Poids 250 Kgs.
Day.	Yarmouth.	1870	6 Oct.	Un. 2 m de long.
Day.	Bac on, près Haisborough	1876	Nov.	Un. 2 m 83 de long.
Gatcombe, puis Day.	Au large de la côte du Norfolk et du Suffolk.	1877	..	Rencontrés à différents reprises avant 1877. Un exemplaire à la côte, un autre à Southwold, conservé au Norwich Museum.
Day.	À la côte du Comté de Kent.	1880	..	Un exemplaire.
Mac Intosh.	Le "Traith", près Pittenweem côte N. du Firth of Forth.	1885	17 Oct.	Pris au chalut. 2 m 74 de long. Poids 340 kgs.

Day, signale encore un crâne recueilli au large de Margate en Mai 1880 et ayant appartenu à un thon qui pouvait avoir plus de 2 mètres de long et peser 250 kgs. Le même auteur nous apprend également que sur la côte du Banffshire, le thon se montre de temps à autre et qu'un exemplaire capturé à Portsoy mesurait près de 2 m 90 de long.

Depuis cette époque (1885) la lecture des Statistiques ou des journaux de pêche montre que le thon n'a pas disparu complètement de la Mer du Nord et que, de temps à autre, on le signale sur quelques points de la côte. Mais, vers 1907, l'attention est de nouveau attirée sur la présence du thon en Mer du Nord, par les pêcheurs harenguiers boulonnais qui ramènent au port de gros thons capturés dans leurs filets à harengs, le long de la côte Est d'Angleterre. Les apports se poursuivant régulièrement pendant les années suivantes, et les poissons ramenés étant bien vendus, les captures s'intensifient de plus en plus: car les pêcheurs ne se contentant plus des thons pris dans les filets à harengs recherchent les moyens pour le capturer activement. En 1921, le thon semble plus abondant que de coutume en Mer du Nord, et du début d'Août à la fin d'Octobre de nombreux exemplaires sont débarqués à Boulogne provenant des différentes pêcheries harenguières; cette abondance de thons est attribuée à l'afflux plus important d'eaux atlantiques chaudes et salées en Mer du Nord. Mais, les années suivantes le thon se montre tout aussi abondant depuis les parages de l'Ile Fair, où il apparaît au milieu de Juillet, jusqu'au Smiths Knoll, dans le Sud de la Mer du Nord où il disparaît vers le milieu d'Octobre. Les senneurs anglais peuvent encore le rencontrer en Septembre—Octobre dans la région des Upper-Scruff et il est également signalé vers la même époque au large d'Heligoland. En 1926, les thons se montrèrent encore particulièrement abondants dans la Mer du Nord, et, un drifter boulonnais ramena jusqu'à 65 thons pris en quelques jours dans les parages du Brucey's-Garden, dans les derniers jours de Septembre.

II. Skagerrak. Côte Scandinave et Baltique.

Auteurs	Lieux de capture	Année	Mois	Observations
Schonefelde.	Embouchure de l'Eckernförder.	1605	Nov.	2 m 58 de long.
Smitt.	Au large Ystad.	1709	..	
Hollberg.	Gothembourg. Rivière Gotha.	1814	..	décrit en 1822. 1 m 72 L.
Lilljeborg	Seland et Øresund.	1839	Sept.	

Auteurs	Lieux de capture	Année	Mois	Observations
Nilsson.	Helsingborg. Abekas (Sund).	1833	4 Oct.	
Smitt.	Echoué dans les eaux peu profondes, au large de Saltholm. (Sund)	1843	..	Long: 2 m 69.
Ekström.	Trouvé mort à Tjörn (île du Bohuslän	1844	23 Août	Long: 2 m 36. Royal Museum.
Malm.	Au large des roches de Gasö (Gullmaren)	1851	Automne	
Malm.	Dans le Skagerrak, retenu dans les algues	1867	15 Oct.	Long: 2 m 485.
Möbius & Heincke, Smitt.	Au large de Stralsund	1869	?	
Smitt.	Au large Ystad.	1878	Octobre	
Smitt.	Ostra Torp.	?	?	
C. A. Hansson	Au large des bouches du Dynekil, près de Strömstad.	1887	Sept.	Long: 2 m 70.

Smitt, Kröyer, Nilsson, Winther, Möbius et Heincke, signalent encore le Thon rouge comme un visiteur occasionnel, pendant les mois d'été dans le Kattegat, le Sound, le Grand et le Petit Belt. Il a été rencontré également à diverses reprises dans le coin S-W de la Baltique (Smitt), mais pas plus loin à l'Est, en Mer Baltique (Möbius et Heincke).

Les annales de pêche ne parlent, avec quelque insistance, de la présence du Thon rouge dans ces régions scandinaves qu'en 1913. En automne, de cette année, il est, en effet, abondant sur le marché de Gothembourg, et pendant la deuxième quinzaine de Septembre sont, à diverses reprises, vendus sur ce marché: 30, 50 et même 150 thons, de 60 à 122 kilogrammes.

En fin de Juillet et en Août 1915, les thons sont encore abondants dans le Skagerrak et de nombreux exemplaires de 1 m 50 à 2 m 20, soit de 110 à 265 kilogrammes sont expédiés sur les marchés de Hambourg et de Altona. 75 thons furent ainsi vendus dans une seule journée sur un de ces marchés[1]).

Depuis cette époque, ces gros poissons ayant désormais un cours

[1]) voir: Von F. Duge. Der Tunfischfang in der Nordsee. Jahresbericht über die Deutsche Fischerei. 1924. p. 216.

sur le marché, leur apparition devient plus régulière. En 1921, les thons sont encore plus abondants et les pêcheurs suédois en prennent fréquemment à la côte. Dans le Skagerrak, les pêcheurs de maquereaux en capturent également dans leurs filets (15—17 Septembre à Scaw). Depuis 1921, la présence du Thon rouge peut être considérée comme régulière dans ces régions.

III. Côtes de Norvège.

L'apparition du Thon rouge sur les côtes de Norvège est devenue d'une telle régularité que les pêcheurs norvégiens ont envisagé divers moyens pour le capturer, et que la mise en conserves de ce poisson a été étudiée et réalisée dans certains ports.

Il apparaît sur la côte W et SW au début de l'été, remonte jusqu'au Lofoten, où M. Sars le signalait déjà en 1870, et atteint même Tromsö (exemple en été 1921 d'après Wollebaek). Vers le Sud, on le rencontre au large de Lindesnaes en Juillet—Août, époque où il a été déjà signalé dans le Skagerrak, puis, plus tard, il remonte vers le Christianiafjord pour atteindre, vers l'Est, les côtes du Bohuslän. Sa présence sur la côte de Norvège dure jusqu'aux mois de Novembre—Décembre.

La présence du Thon rouge dans cette région a d'ailleurs été signalée de longue date.

R. Collett dit que de 1760 à 1770 le thon s'est présenté chaque année et en quantités abondantes à l'Est de Lindesnaes. Les premières captures signalées sur la côte Ouest, dans le Söndmör, remontent à 1788 : 8 ou 10 thons y furent capturés cette année. Ström écrit, en 1892, que le Thon rouge était fréquemment capturé, le siècle dernier, dans le Hjörund Fjord (Söndmör) pris dans les filets de harengs ou attaqué au harpon par les pêcheurs. Au 19ème siècle, diverses captures sont encore notées par les différents auteurs norvégiens: en 1881 dans le Geirangerfjord; en 1887, à Herløv, où un thon de 325 Kilogrammes est capturé et dans l'estomac duquel fut trouvé trois saumons (Collett). En 1890, 30 Juillet, à Tønsberg où deux individus sont capturés: respectivement de 3 m 13 et de 2 m 50 de long (Collett); puis encore en 1894 à Bjørnefjord, en dehors de Bergen (Collett). Actuellement, sa présence est considérée comme normale, sur la côte, pendant les mois d'été.

Ajoutons encore, d'après une information orale de Mr. Atkinson, que le Thon rouge remontrait vers le Nord, bien au delà de Tromsø. Il a été en effet signalé à diverses reprises par les chalutiers opérant au large de la côte Mourmane[1]).

[1]) voir: Expedition für Wissenschaftlich-Praktische Untersuchungen an der Murman Küste — Band I — 1902.

Un thon de 223 centimètres capturé le 21 Août (an calendrier russe — soit le 2 septembre) 1898, sur la côte Est d'Ekaterina Harbourg.

IV. Entrée occidentale de la Manche, Manche et Mer d'Irlande. Côte Ouest d'Irlande et d'Ecosse. Islande.

J. Couch, Yarrell, Day, notent le Thon rouge comme apparaissant régulièrement des côtes de Cornouailles: autour du Cap Cornwall, de Lands End et des Iles Scillys, et jusqu'à la côte du Devonshire, en Juillet, Août, et Septembre. Les mêmes auteurs le signalent encore comme fréquentant les îles et la côte Ouest et Nord d'Ecosse pendant les mêmes mois. Les pêcheurs de cette région les appellent: "Mackrelsture" ou "Mackerelstaur" (Yarrell) — Trad: grand maquereau —.

Des captures isolées en différents points ont encore été relevées:

Auteurs	Lieux de capture	Année	Mois	Observations
Pennant.	À Inverary (Loch Fyne).	1769	été	Poids: 208 kgs.
Dr. Scouler	Greenock (entrée du Gair Loch).	1831	Juillet	Long: 2 m 98, conservé à l'Andersonian Museum. Glasgow.
Yarrell.	Abondant sur côtes de Cornouailles.	1840—1841	..	
Thompson.	Côte du Comté de Down. (Irlande).	1841	..	
Jacob.	À l'entrée de la baie de Dublin.	1842	Automne	Long: 2 m 50, Circonférence 1 m 62, Poids: 136 kgs.
Yarrell.	Dartmouth.	1851	Mars	Pris dans filets à maquereaux.
Day.	Dawlish (Devonshire)	1868	Sept.	Long: 2 m 70, Poids 200 kgs.
Day.	Baie de Plymouth.	1873	22 Juil.	Long: 2 m 70.

Rappelons encore que Duhamel du Monceau cite, en 1769, avoir mangé du Thon rouge à Brest. Il considère le fait comme rare.

Renseignements pris, le Thon rouge n'est plus si rare au accores du plateau continental. A la Grande Sole, sur la Petite Sole et le Banc de la Chapelle, les chalutiers rencontrent parfois en Novembre—Décembre des bancs de Thons rouges s'ébattant en surface. Le fait s'est encore confirmé cet hiver, début de Décembre 1926. Il apparaît même parfois au voisinage de la côte et il nous fût signalé à l'entrée de la baie de Douarnenez au cours des précédents hivers (Novembre—Décembre). Un

chalutier travaillant dans la fosse de la Hève, en Manche, ramena à la fin de Novembre 1921, en même temps qu'une tonne environ de harengs, un gros thon. Ce thon fût vendu à Boulogne.

Le 27 Juin 1925, un groupe de thons rouges est aperçu en surface par un chalutier boulonnais dans le Sud des Blaskets (Côte Sud-Ouest d'Irlande). Vers la même date, un autre groupe est repéré, par un autre chalutier, 40 milles environ dans le Sud de Galley Head (Irlande). Un peu plus au Nord, sur la pêcherie de harengs des Smalls, les chalutiers en signalent encore fin de Juillet et Août. Au cours de la croisière de la "Tanche" et en fin d'Août 1926, nous avons pu voir un groupe de thons rouges au large de l'entrée du Lough Swilly, Nord de l'Irlande. Vers la même date, un chalutier anglais en capturait un au large de Dubh Artach et le rapportait au marché de Fleetwood.

En Islande, enfin, plusieurs auteurs signalent encore la présence du Thon rouge:

Auteurs	Lieux de capture	Année	Mois	Observation
S. Palsson.	À Eyjafjallasandur (Côte Sud).	1897	11 Nov.	
Gröndal.	À Eyrarbakk (Côte Sud)	1880	7 Sept.	Long: 1 m 80.
B. Bløndal.	À Leirhöfn (Melrakkasljetta, Côte Nord).	1814	Nov.	Long: 1 m 80.
S. Sivertsen.	Près de Reykjanes (Côte Ouest)	1898	Nov.	Long: 2 m 40.
B. Saemundsson	Au Jökuldjup (Baie de Faxe).	1906	Été	Un crâne.

Des renseignements précis nous manquent pour confirmer la présence actuelle du Thon rouge dans cette région.

Cette bibliographie, qui ne peut évidemment être complète, montre que l'apparition du Thon rouge dans la partie septentrionale de l'Atlantique Nord n'est pas de date récente. Dès le début du 17ème siècle (1605—Schonefelde) sa présence est signalée, et, fait intéressant à noter, les apparitions sont de plus en plus fréquentes à mesure que progresse la science ichthyologique. A l'orée du 20ème siècle quand l'industrie de la pêche cherche à retirer le plus grand profit des produits

de la mer, l'attention du pêcheur est attirée davantage vers ces gros poissons qui peuvent être d'un rapport rémunérateur et aux captures accidentelles viennent s'ajouter des prises faites par des moyens divers. Sur le marché, les Thons rouges apparaissent en plus grand nombre. Les biologistes doivent-ils pour cela conclure à une extension nouvelle de l'habitat de ce poisson? Nous ne le croyons pas. Le Thon rouge n'est pas un être exceptionnel dans l'Atlantique Nord et ses mers tributaires. Il a échappé longtemps aux investigations des naturalistes et les progrès de la pêche leur ont fait constaté sa présence régulière si ce n'est abondante.

Il importe encore de remarquer immédiatement que, quelques soient les lieux de capture de ces Thons rouges, ils se présentent isolément ou par petits groupes. De plus, jamais on n'a pu trouver de thons avec des glandes sexuelles tant soit peu développées. Il est donc un fait évident: le Thon rouge ne se reproduit pas dans ces régions. Couch, Day, Mac Intosh, constatant ce fait, ont conclu que ces thons étaient soit des individus vivant solitaires, (comme certains éléphants), soit des individus ayant survécu à l'influence du sexe et fatigués de la compagnie de leurs semblables ou chassés par eux[1]). Cet état particulier de l'appareil génital, leur formation isolée ou par petits groupes, leur voracité qui leur fait poursuivre avec avidité les bancs de poissons (Sardines, maquereaux, harengs, belones, scomberesox suivant les régions) jusque dans les filets ou à terre, enfin, la périodicité annuelle, de Juin à Décembre de leur apparition dans les différentes régions où ils ont été signalés, laissent plutôt penser, d'après ce que nous connaissons sur la biologie du Thon rouge depuis les travaux de Mr. Roule, qu'on se trouve en présence de Thons erratiques, éparpillés après la ponte dans ce vaste domaine à la recherche d'une nourriture abondante, jusqu'à ce qu'ils redeviennent génétiques, au printemps, et se rassemblent sur une aire de ponte qu'il reste à préciser.

Diagnose du Thon Rouge de la Mer du Nord.

H. Heldt a précédemment établi (Notes et Mémoires de l'Office Scient. et Techn. des Pêches Marit. No. 22. 1923) que le Thon rouge de la Mer du Nord n'était autre que le Thon vulgaire ou Thon de la Méditer-

[1]).... It has been surmised that the large and solitary tunnies, which are occasionally found off our coast, are such as for some cause have parted company from others of their kind. It may be that having outlived the influence of sex, they have wearied of the further society of their fellows: or else that, like the rogue elephants, they have been expelled. (Day: The Fishes of Great Britain and Ireland. 1880—1884. Vol. I, p. 95.)

ranée (*Thunnus Thynnus* L.). Les descriptions de MALM: d'après un exemplaire capturé dans le Skagerrak, le 15 Octobre 1867, et de A. T. MASTERMAN d'après un thon pris le 16 Octobre 1885 dans le Firth of Forth ne peuvent que confirmer cette opinion. Nos observations portant sur douze thons capturés sur les pêcheries harenguières de la Mer du Nord au cours des saisons de 1925 et 1926 concluent dans le même sens.

Le tableau ci-dessous donne les différentes moyennes obtenues dans le calcul des proportions des exemplaires mensurés, comparativement aux proportions données par H. HELDT dans son "Résumé sur nos connaissances actuelles sur le Thon Rouge" (*Thunnus thynnus* L.). Rap. et Proc. Verb. Commission Internationale pour l'Explor. de la Mer Méditerranée. Volume I. 1926.

	H. HELDT	Moyennes
Longueur totale du corps divisée par la hauteur du tronc	4 à 4¼	4,28
Longueur totale divisée par longueur de la tête	environ 4	4,21
Position de la 1ère dorsale	au dessus et un peu en avant de la pectorale	
Position de l'anale	en arrière de la deuxième dorsale	
Longueur des pectorales divisée par longueur espace postorbitaire	plus grand que 1	1,27
Longueur totale divisée par longueur des pectorales	5½ à 6¾	6,28
Longueur de la pectorale divisée par sa largeur à la base	3 à 4	3,74
Hauteur du tronc divisée par hauteur du premier rayon de la dorsale	2 à 2½	2,40
Longueur de la tête divisée par diamètre de l'œil	7 à 9	9,40
Espace préorbitaire divisé par diamètre de l'œil	2 à 3	2,60

Les proportions suivantes ont également été établies:

Longueur totale du corps divisée par la distance du bout du museau à l'extrémité antérieure de la nageoire dorsale: *3,6.*

Longueur totale du corps divisée par la distance du bout du museau à l'extrémité antérieure de la nageoire anale: *1,7.*

Longueur totale du corps divisée par la distance du bout du museau à la base de la pectorale: *4,0.*

Le nombre des vertèbres a pu être compté sur un exemplaire et égal à *39*.

Les caractères dentaires sont bien les mêmes que ceux du thon de la Méditerranée: Le prémaxillaire et le dentaire portent de chaque côté une seule rangée de dents petites et crochues, au nombre de 80 environ de chaque côté de chaque mâchoire. Le vomer porte une bande médiane de petites dents, deux plages de dents palatines sont également visibles et le mésoptérygoidien est également denté dans sa partie médiane.

La formule des rayons des nageoires est tout à fait comparable à celle donnée par H. Heldt pour *Thunnus thynnus* L. de la Méditerranée.

La première dorsale a le plus souvent 14 rayons, nous avons cependant rencontré quelques exemplaires avec 13 (Moyenne établie: 13,83).

La deuxième dorsale a 14 rayons, parfois 13 (Moyenne: 1/12,83).

Le nombre des pinnules dorsales varie de 8 à 10 (Moyenne 8,9).

Pectorales avec de 30 à 34 rayons mous.

Ventrales: 6 rayons dont une épine et 5 mous.

Anales: de 11 à 15 rayons (Moyenne: 2/11;8).

8 à 9 pinnules anales.

19 à 23 rayons ont pu être comptés dans chaque moitié de la nageoire caudale.

La taille des thons capturés en Mer du Nord et dans les régions avoisinantes oscille le plus souvent entre 2 et 3 mètres. Quelques individus plus petits ont de 1 m 50 à 2 mètres. Nous avons pu voir des exemplaires dépassant trois mètres. Leur poids est également très variable et varie suivant la taille de 100 à 300 kilogrammes et même au delà, mais se maintient d'une façon générale autour de 250 kilogrammes.

Ce sont donc des individus adultes, et même âgés, puisque d'après les travaux de F. de Buen un thon de 2 m 06, pesant 119 kilogrammes peut être âgé de douze ans.

Il n'y a rien de bien intéressant à noter sur la nourriture de ces Thons rouges. Ils se rencontrent toujours là où il y a beaucoup de poissons: Bancs de harengs en Mer du Nord, bancs de maquereaux dans le Skagerrak où ils poursuivent encore les orphies. Sur la côte de Norvège, les bancs de sprats et de harengs les attirent. Un thon capturé à Herløv avait encore dans l'estomac trois saumons. Sur les côtes d'Ecosse, ils poursuivent les bancs de harengs jusque dans les lochs. Dans le "Traith" de Pittenweem, un thon pris au chalut avait dans l'estomac: 3 petits haddocks, 2 limandes (common dabs) et 2 limande-soles (lemon dabs) (Mac. Intosh). Autour de la Cornouaille Anglaise, ils poursuivent les bancs de petits poissons: sardines, balaous (Scomberesox saurus) ou de harengs.

D'après Osbeck, le Thon rouge rechercherait avec avidité les céphalopodes (Seiches: cuttle). F. de Buen a, d'ailleurs, noté la présence de Loligo dans l'estomac de thons pris en Espagne, et, l'abondance d'Ommatostrephes sagittatus aux accores du plateau continental et dans les parages de la Grande Sole en Novembre et Décembre dernier, pourrait bien être une raison de leur présence dans ces parages.

Conditions Hydrologique rencontrés dans le Domaine fréquenté par les Thons Erratiques dans l'Atlantique Nord-Est.

Au point de vue biologique, nous avons admis que les Thons rouges rencontrés dans l'Atlantique Nord étaient des Thons erratiques éparpillés après la ponte, et, que leur présence était conditionnée par la présence d'une nourriture abondante: bancs de harengs, de maquereaux, de sardines etc.

Cette condition n'est pas unique, car l'extension de leur domaine pourrait, dès lors, être bien plus considérable. D'autres conditions, d'ordre hydrologique, semblent également présider à leurs déplacements. Il importe de préciser ces conditions.

Si on considère, tout d'abord, les aires de distribution des Thons rouges et la date de leur apparition dans les régions considérées, on constate que leur arrivée coïncide avec l'extension des eaux atlantiques dans la région.

Les travaux d'Ed. le Danois ont établi que chaque année les eaux atlantiques, chaudes et salées (salinité $> 35{,}5\ ‰$) manifestaient une tendance à se rapprocher des côtes en empiétant sur le domaine continental et en refoulant les eaux continentales. Ce phénomène qu'il a appelé Transgression débute en Juin au large de nos côtes pour se poursuivre jusqu'en Novembre. La transition entre les eaux atlantiques et les eaux continentales, à température variable et de faible salinité, n'est pas brusque et Le Danois a donné le nom d'eaux de la pente atlantique, aux eaux de salinité de 30 à $35{,}5\ ‰$ et de température assez basse qui font la transition entre les eaux atlantiques vraies et les eaux continentales. Ces eaux participent aux mouvements transgressifs en précédant, le plus souvent sur le fond, à cause de leur densité relativement élevée, les eaux atlantiques vraies.

En résumé, chaque année, dès le début de Juin — et le phénomène se poursuit jusqu'en Novembre — on peut constater une extension sur le plateau continental, des eaux atlantiques: eaux atlantiques vraies et eaux de la pente atlantique. Après Novembre, les eaux atlantiques régressent, abandonnent le plateau continental. C'est la période de Stabilisation Hivernale. L'apparition et la disparition des Thons rouges

dans les régions signalées coincident avec l'extension et le retrait des eaux atlantiques dans ces régions, et surtout, avec les mouvements des eaux de la pente atlantique, particulièrement en Mer du Nord. Nous pouvons donc admettre ce domaine des eaux atlantiques (eaux atlantiques vraies et eaux de pente) comme étant le leur, et que l'extension de ce domaine au cours des transgressions annuelles permet une extension plus grande de l'aire de distribution des Thons rouges erratiques.

C'est ainsi que l'apparition des Thons rouges au Sud de l'Irlande, au large des Blaskets, coincide avec le début de la transgression océanique dans cette région: fin de Juin—Juillet. La présence des thons à Smalls, en Août, coïncide encore avec l'arrivée des eaux atlantiques à l'entrée sud de la Mer d'Irlande. A la pointe de Cornouailles, les thons arrivent au début de Juillet avec les eaux de transgression et restent dans cette région jusqu'au retrait de ces eaux: Octobre. On les retrouve en Novembre—Décembre au accores du Plateau continental (Grande Sole, Petite Sole, Banc de la Chapelle), quand les eaux atlantiques abandonnent la plate forme continentale. Leur arrivée au Nord de l'Irlande, sur les côtes Ouest et Nord de l'Ecosse (Juillet) correspond encore avec le début de l'extension des eaux océaniques.

En Mer du Nord, le phénomène est encore très net. A mesure que les eaux à 35 $^{0}/_{00}$ avancent vers le Sud (Fig. 2), les thons apparaissent de même dans des régions de plus en plus méridionales. Dès la fin de la première quinzaine de Juillet, les pêcheurs les signalent au voisinage de Ile Fair, entre les Iles Shetland et les Orkneys. Dès le début d'Août, on en voit dans l'Est du Moray Firth et de Buchanness, fin d'Août, au large de North-Shields, en Septembre dans les parages du Brucey's Garden jusqu'au Dowsing, au Sud. Ils apparaissent encore, mais de façon plus irrégulière, et ceci doit dépendre de l'extension plus ou moins grande des eaux atlantiques vers le Sud de la Mer du Nord, jusqu'au Smiths Knoll, point qu'on peut considérer comme la limite d'extension méridionale du Thon rouge en Mer du Nord. En Septembre—Octobre, ils sont encore abondants sur les fonds de pêche de l'Upper Scruff et un peu plus tard on les trouve parfois au large d'Heligoland.

Dans le Skagerrak, leur arrivée coincide toujours avec l'extension des eaux salées: Juillet et Août et il en est de même sur les côtes de Norvège; leur disparition, dans ces régions, correspondant également au retrait de ces eaux océaniques.

En Islande, enfin, leur présence sur la côte Nord comme sur la côte Sud est signalée au moment où les eaux salées approchent de la côte, c'est à dire au moment du maximum de salinité dans la région: soit

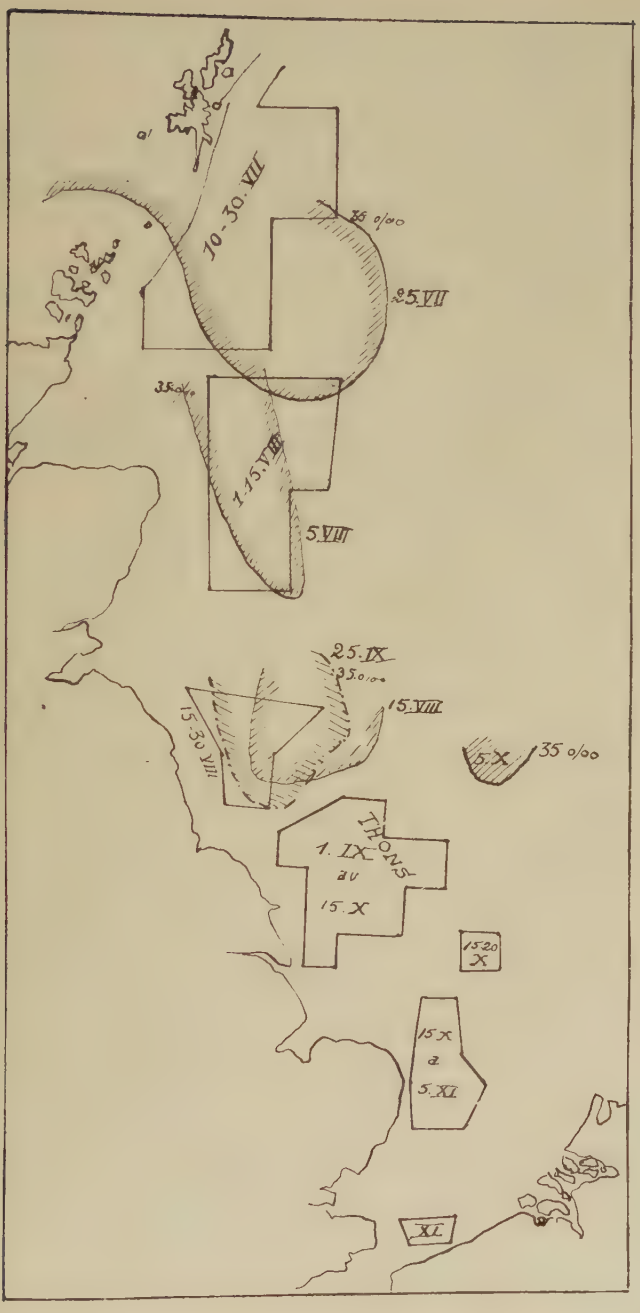


Fig. 2. Distribution du Thon Rouge en Mer du Nord. Dans chacune des zones de pêches, la limite des eaux à 35 °/₀₀ est indiquée par une courbe bordée de hachures. Le quantième du mois est indiqué en chiffres arabes, le mois en chiffres romains.

en Octobre—Novembre. (Voir: Martin Knudsen, puis J. P. Jacobsen & A. J. C. Jensen [1]) Fig. 3).

Si nous avons accordé quelqu'importance au facteur salinité dans la distribution du Thon rouge dans l'Atlantique Septentrional, en nous basant sur ce fait que l'apparition de ce poisson dans une région coïncidait avec le maximum de salinité dans la même région, il ne peut en être de même du facteur température.

Les Thons rouges apparaissent bien dans le Skagerrak, le Kattegat et le Belt au moment du maximum de température dans cette région, il en est le plus souvent de même en Mer du Nord, mais, la présence de thons en Novembre sur les côtes d'Islande, leur extension sur les côtes de Norvège jusqu'aux Lofoten et plus au Nord encore jusqu'à la côte Mourmane nous oblige d'admettre que la sténothermie des thons erratiques doit être très atténuée. On en trouve, en effet, dans des eaux dont la température varie de 7 à 15 degrés. De plus, en Islande par exemple, (Fig. 3) si la présence de thons en Octobre—Novembre correspond au maximum de salinité dans la région, elle ne correspond pas au maximum de température qui a lieu deux à trois mois plus tôt. C'est pour cette raison que nous avons plutôt admis que le domaine des thons erratiques s'étendait non seulement dans les eaux atlantiques vraies, chaudes et salées, mais encore dans les eaux de la pente atlantique: eaux à salinitée de 30 à 35 $^0/_{00}$ et de température plus basse: 8 à 12 degrés.

L'importance du facteur Salinité peut être, elle même, sujette à discussion. Les thons s'écartent parfois des eaux salées et on les trouve dans des eaux à salinité bien inférieure à 35 $^0/_{00}$. C'est le cas en Mer du Nord, et particulièrement dans le Skagerrak, le Kattegat et le Belt.

En Mer du Nord, le Thon rouge fréquente les pêcheries harenguières où les pêcheurs les capturent dans leurs filets ou au harpon le long du bord. La figure 2 montre la position des pêcheries françaises et hollandaises au cours de la saison dernière de 1926. Dans chacune des régions de pêches nous avons tracé l'isohaline 35 $^0/_{00}$ en surface, à l'époque considérée, ceci d'après les résultats des croisières du Conseil International pour l'Exploration de la Mer: Bulletin Hydrographique Trimestriel 1926. On peut remarquer que, si dans les pêcheries du Nord: Shet-

[1]) Martin Knudsen: Contribution to the Hydrography of the North Atlantic Ocean. Medd. fra Kommiss. for Havundersøgelser. Série Hydrografi. Bind I. No. 6. København, 1905.

J. P. Jacobsen and Aage J. C. Jensen: Examination of Hydrographical Measurements from the Research vessels "Explorer" and "Dana" during the Summer 1924 Rapports et Proc. Verb. Cons. Intern. Explor. de la Mer. Vol. XXXIX. 1926.

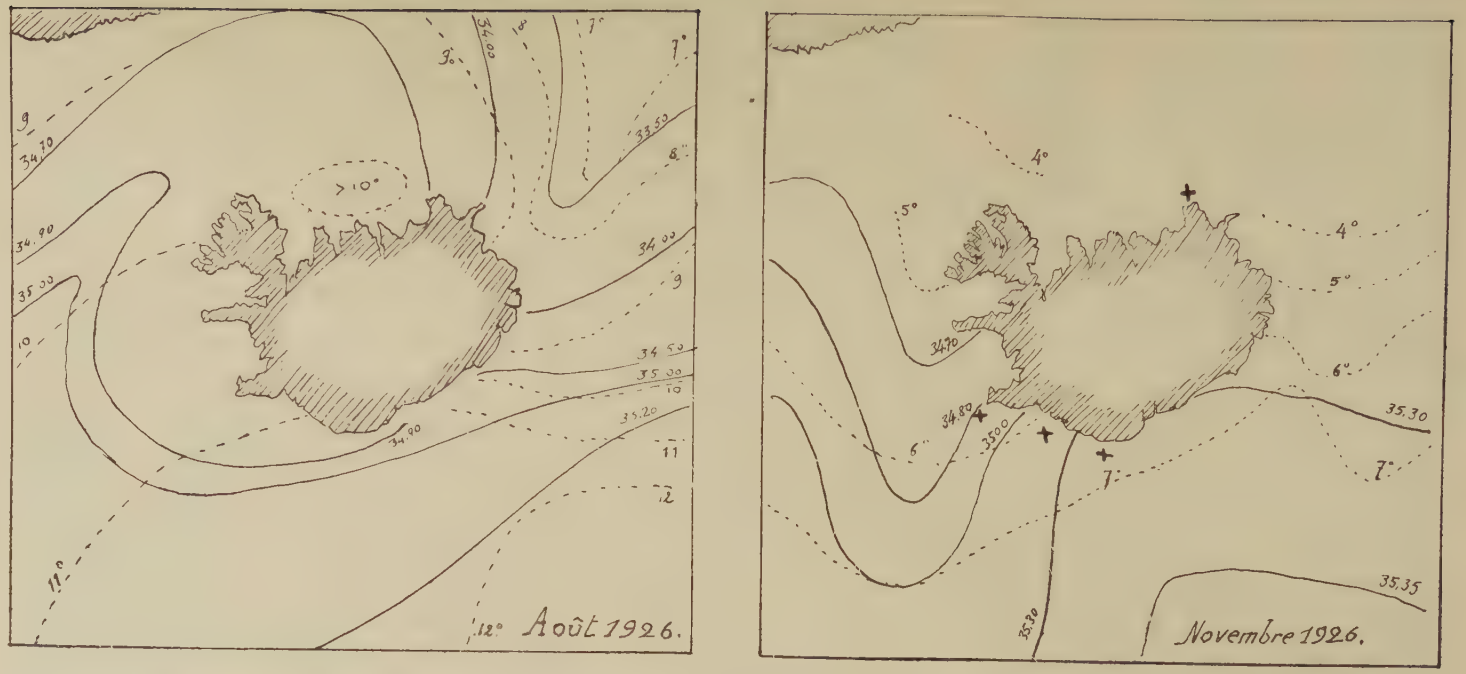


Fig. 3. Distribution du Thon Rouge sur les côtes d'Islande (+) et distribution des isothermes et isohalines en Août et Novembre d'après le Bulletin Hydrographique Trimestriel 1926.

land—Orkneys, Est de l'Ecosse, l'isohaline 35 $^0/_{00}$ empiète largement sur la zone de pêche du hareng et aussi du thon, il n'en est pas de même dans la partie Sud: Brucey's Garden et alentours, où cette isohaline est nettement plus au Nord-Est. Les Stations faites par le "Georges Bligh" dans cette région: 3 Octobre 1926 (Bulletin Trimestriel No. 4. 1926) montrent une salinité maximum de 34,62 en surface (par 54,53 N. et 0,38 E. Gr.), la salinité variant dans la région de 34,40 à 34,62, en surface comme en profondeur. C'est pourtant dans les parages du Brucey's Garden que se firent, en 1926, les plus belles captures de Thons rouges par les bateaux français.

Dans le Skagerrak, le Kattegat, et le Belt, les thons apparaissent en Août et Septembre, c'est à dire au moment où la température de l'eau est à son maximum:

16 à 17 degrés en surface: 1er au 4 Août,
15 à 17 degrés à 10 mètres: 10 au 15 Août,
13 à 16 degrés à 20 mètres: 10 Août au 10 Septembre,
11 à 15 degrés à 40 mètres: 20 Août au 20 Septembre[1]),

et où la salinité atteint également son maximum en profondeur: Août à Novembre. Mais cette salinité qui atteint 35 $^0/_{00}$ dans le Nord du Kattegat va en diminuant à mesure qu'on s'avance vers le Sud et qu'on pénètre dans le Belt, pour descendre au dessous de 20 $^0/_{00}$. Des thons ont cependant été signalés à diverses reprises dans le Kattegat et le Belt. (Voir Fig. 4 et 5 A et B pages 325, 26 et 27).

Dans les fjords de Norvège, enfin, des thons sont aperçus en surface pendant les mois d'été et au début de l'automne, la salinité y est encore inférieure, tout au moins en surface, à 35 $^0/_{00}$.

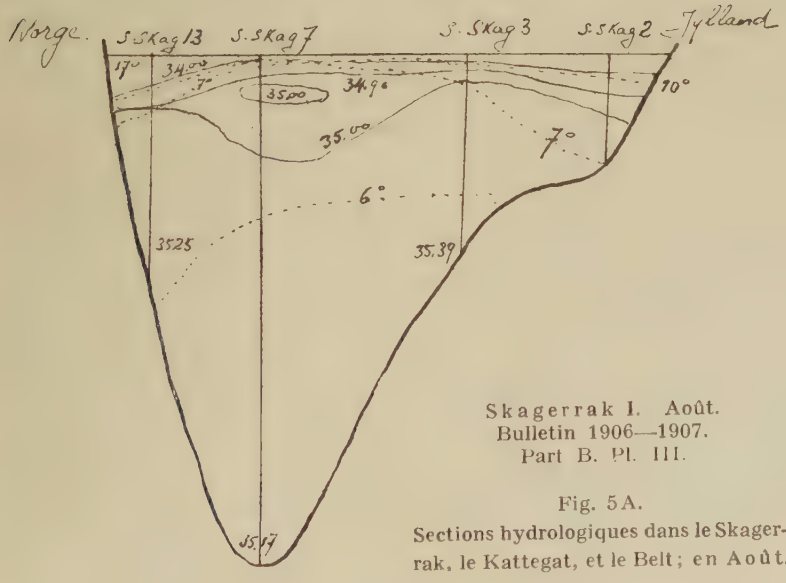
En définitive, on doit bien admettre que la sténohalinité de ces thons erratiques est aussi fort atténuée puisqu'ils peuvent séjourner, au moins temporairement, dans des eaux de salinité bien inférieure à la normale.

Ces constatations viennent-elles en contradictions avec les importants travaux du Professeur Roule sur la biologie du Thon Rouge de la Méditerranée, établissant que le thon recherche les eaux tièdes et salées? Nous ne le pensons pas.

Le fait que le thon puisse séjourner temporairement dans des eaux à température et à salinité inférieures à celles du milieu qu'il fréquente normalement ne doit pas faire oublier la cause première de l'apparition du thon dans ces eaux. Elles est intimement liée à l'arrivée, dans la

[1]) Résultats basés sur les observations portant de 1880 à 1907: J. P. Jacobsen: Mittelwerte von Temperatur und Salzgehalt. Bearbeitet nach hydrographischen Beobachtungen in Dänischen Gewässern 1880—1907. Kopenhagen 1908.

Fig. 4.
Distribution du Thon Rouge dans le Skagerrak, le Kattegat, le Belt. Les lieux de capture sont approximativement représentés par le mois où s'est faite la capture. Les droites indiquent la direction des sections hydrologiques pratiquées dans cette région: soit du Nord au Sud: Skagerrak I; Kattegat I; Belt I.



Skagerrak I. Août.
Bulletin 1906—1907.
Part B. Pl. III.

Fig. 5A.
Sections hydrologiques dans le Skagerrak, le Kattegat, et le Belt; en Août.

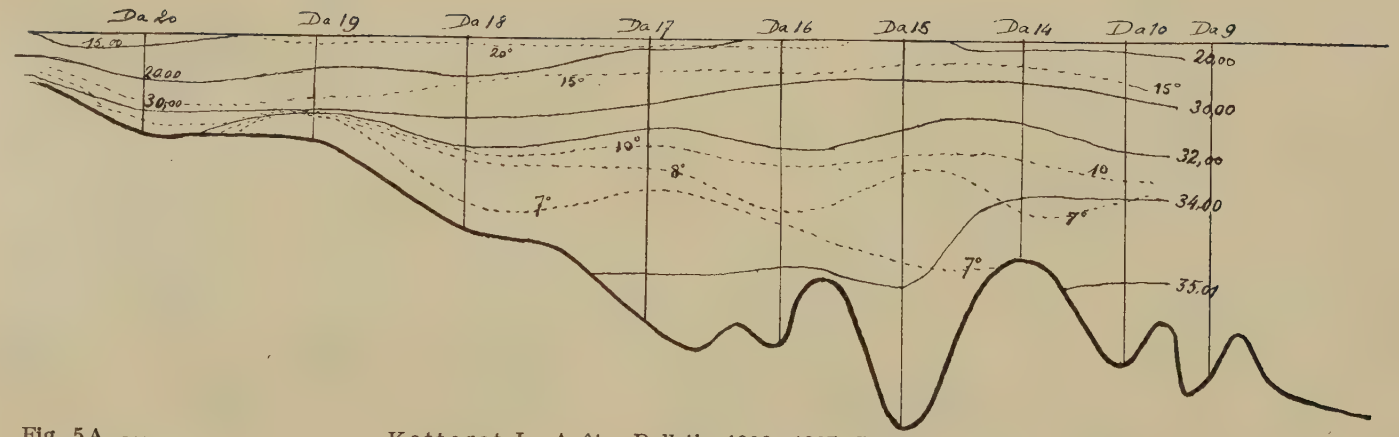
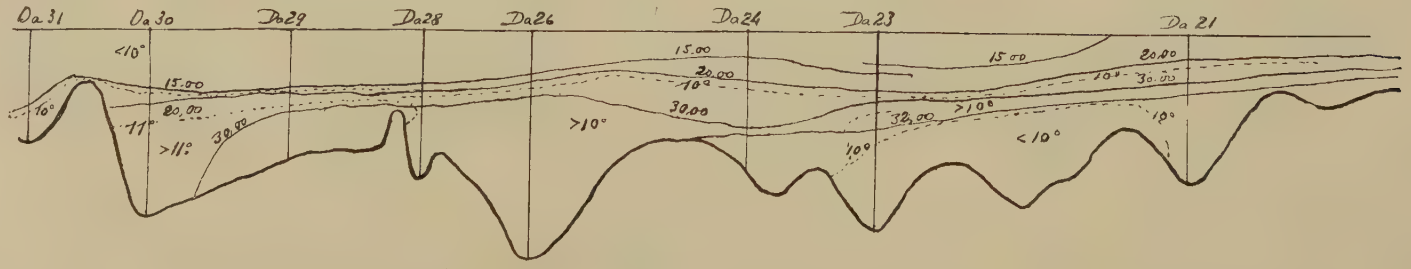
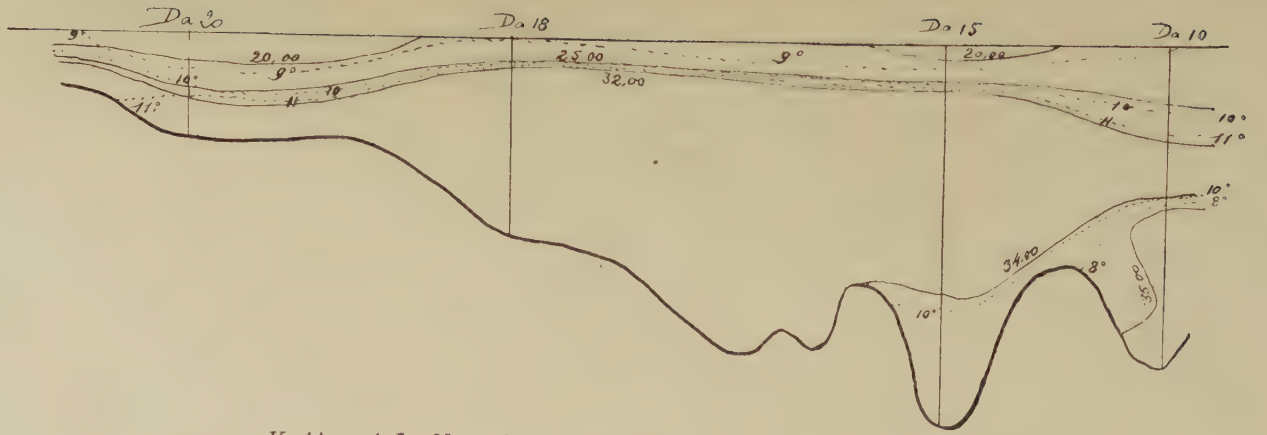


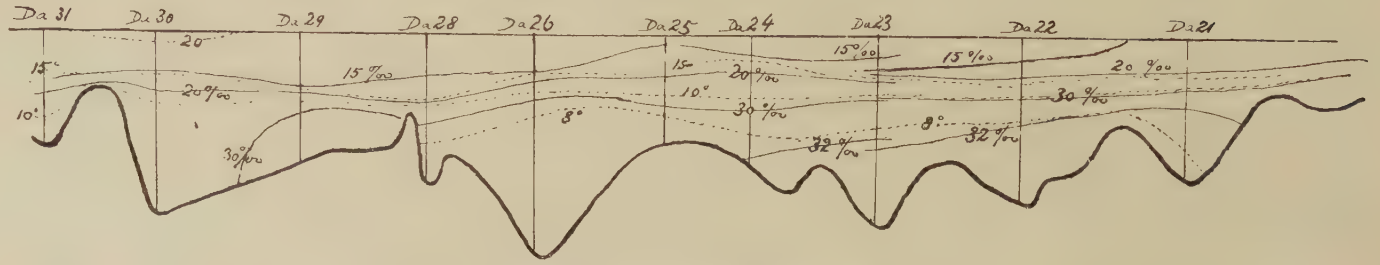
Fig. 5A. — Kattegat I. Août. Bulletin 1906—1907. Part B. Pl. III.



Belt I. Août. Bulletin 1906—1907. Part B. Pl. III.



Kattegat I. Novembre. Bulletin 1906—1907. Part B. Pl. XI.



Belt I. Novembre. Bulletin 1906—1907. Part B, Pl. XI.

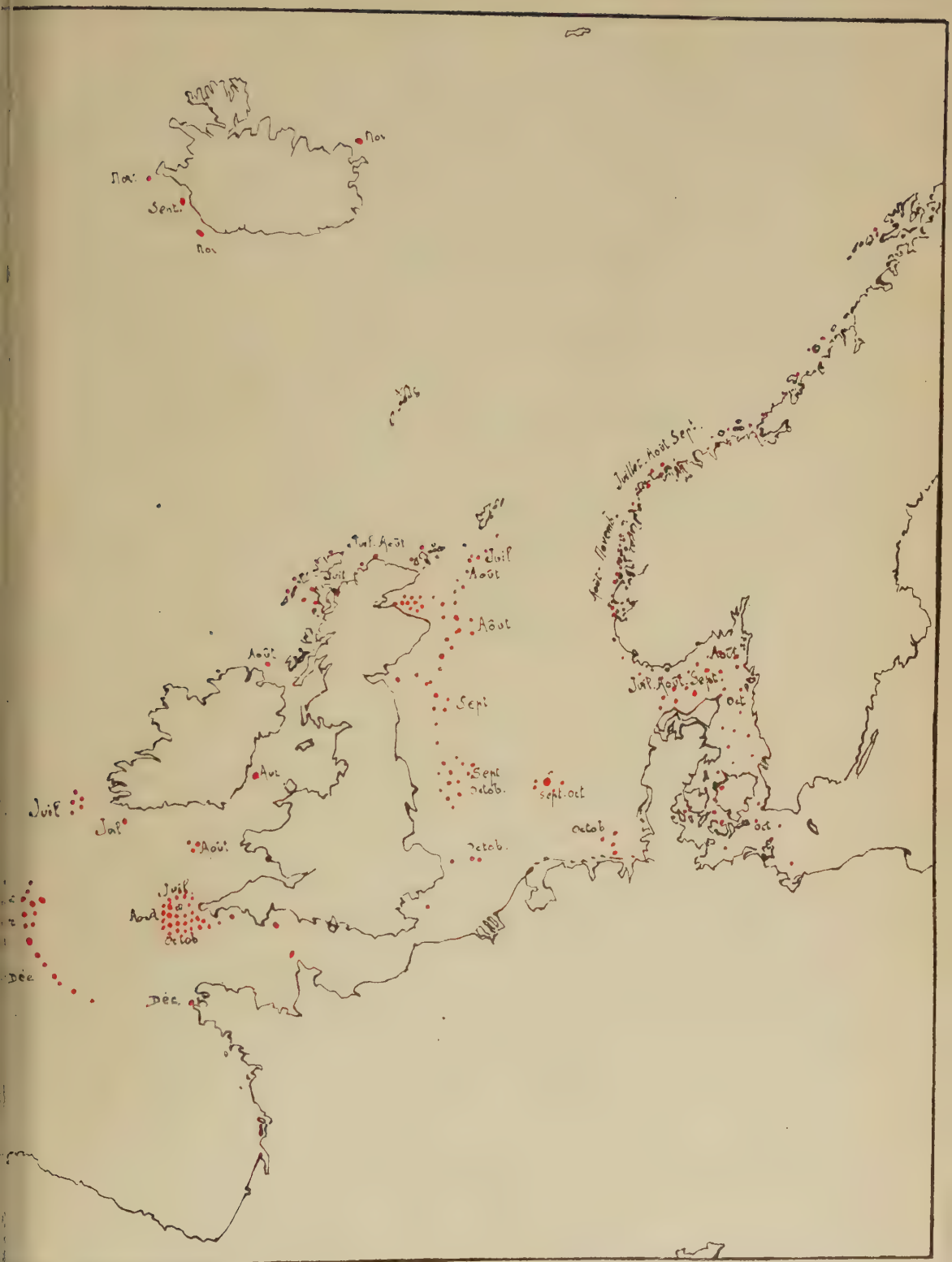
Fig. 5B. Extension des eaux salées dans le Skagerrak, le Kattegat, et le Belt. Comparer avec les sections hydrologiques d'Août.

région, d'eaux atlantiques d'une température et d'une salinité plus élevées que celles qui s'y trouvent habituellement. Le thon arrive avec la transgression atlantique et disparaît avec elle. Son domaine normal reste donc bien défini. Il peut cependant s'en écarter. Pendant leur période de dispersion trophique, les thons erratiques ne montrent plus une sensibilité très grande à la salinité et à la température, car un besoin impérieux les guide: la recherche d'une nourriture abondante; les besoins du milieu intérieur l'emportent sur l'action du milieu extérieur, tandis qu'au moment de la maturité sexuelle les conditions extérieures agissant sur une sensibilité accrue l'emportent sur les besoins du milieu intérieur.

Ceci peut expliquer pourquoi la présence de bancs de poissons dans un domaine océanique voisin de leur habitat normal peut les entraîner à sortir de cet habitat. Le thon est attiré par les bancs de poissons. Ces bancs doivent: ou dégager des émanations, ou émettre des radiations qui se répandent dans le milieu marin et exercent sur les prédateurs (non seulement les thons) une action attractive. Ces émanations de nature chimique, ou ces radiations de nature vibratoire, exercent leur action par l'intermédiaires d'organes sensoriels, que dans l'impossibilité actuelle de préciser l'homme a comparé à ses organes du goût et de l'odorat. Ces organes sensoriels sont hypersensibilisés pendant la période de dispersion trophique des thons, tandis que la sensibilité aux variations de températures et de salinités est au contraire atténuée. Au moment de la concentration de reproduction le phénomène inverse se produit, les thons deviennent hypersensibles aux variations externes de sensibilité et de température, tandis que leur sensibilité attractive aux radiations ou émanations des bancs de poissons est atténuée.

Résumé et Conclusions.

Le Thon Rouge (*Thunnus thynnus* L.) n'est pas un animal d'introduction récente dans la Faune de la Mer du Nord et de la partie septentrionale de l'Atlantique Nord. Ils y ont été signalés dès le 17ème siècle et la fréquence de leur apparition va en augmentant avec les progrès de la science ichthyologique et de l'industrie des pêches. Il est reconnu qu'actuellement ils apparaissent périodiquement en Mer du Nord, dans le Skagerrak, le Kattegat, sur les côtes de Norvège, sur les côtes Nord et Ouest d'Irlande, à l'entrée Occidentale de la Manche, au large des côtes de Cornouailles et sans doute encore en Islande. Cette périodicité de leur apparition doit être étendue aux temps passés et on ne peut plus admettre le Thon Rouge (*Thunnus thynnus* L.) comme un visiteur exceptionnel dans ces régions.



Distribution et places de capture du Thon Rouge (*Thunnus thynnus* L.) dans l'Atlantique Nord Est et au Nord du 48ème degré de Latitude.

Au point de vue biologique, le Thon Rouge des Mers du Nord correspond morphologiquement au Thon Rouge de la Méditerranée et de la côte Sud-Ouest d'Espagne. Leurs caractères sont identiques. La seule différenciation ne peut provenir que d'un état physiologique différent: Les thons de la Mer du Nord et autres régions septentrionales sont des thons erratiques, dans la période de dispersion trophique, tandis que les thons de la côte Sud d'Espagne et du Portugal: Algarve et Golfe de Cadiz, sont des thons génétiques en concentration de reproduction.

Nous admettons provisoirement, d'ailleurs, que cette région des Algarves et du Golfe de Cadiz soit le point de concentration, au moment de la ponte, des thons erratiques rencontrés plus au Nord: Mer du Nord etc. C'est en effet le fond de ponte le plus septentrional connu dans l'Atlantique pour le Thon Rouge.

Au point de vue hydrologique: la distribution des Thons erratiques dans les eaux septentrionales est en relation avec les transgressions atlantiques annuelles. Le domaine normal du Thon Rouge est le domaine atlantique: eaux atlantiques vraies plus eaux de la pente. L'extension des eaux atlantiques dans une région permet leur arrivée, le retrait de ces eaux provoque leur départ.

Les Thons erratiques peuvent cependant quitter le domaine atlantique, pour pénétrer dans des eaux continentales à température et salinité faibles.

Leur sensibilité aux variations de salinité et de température est atténuée pendant la période de dispersion trophique, par contre, leur sensibilité aux émanations ou radiations émises par d'autres êtres vivants dont ils font leur proie est accrue par les besoins du milieu intérieur. C'est ce qui les entraîne au dehors de leur habitat normal qu'ils doivent toutefois rejoindre au bout d'un certain temps plus ou moins long.

Cette étude ne peut avoir aucun caractère définitif. L'attention des naturalistes sur les déplacements du Thon en Mer du Nord n'a été attirée que tout récemment et les documents sont encore insuffisants pour pouvoir en tirer des conclusions plausibles. Si nous avons émis quelques hypothèses en se basant sur un petit nombre seulement de faits précis, ce n'est que pour en provoquer l'examen et la critique.

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The Surface Sampler, an Apparatus for the Collection of Samples from the Sea Surface from Ships in Motion.

With a note on surface temperature observations.

By

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The apparatus here to be described was designed to facilitate the collection of surface water samples from ships in motion, the samples being obtained to provide material for salinity and temperature determination. The need for some such apparatus sprang from the realisation that the use of an ordinary iron bucket was not always a simple task, the difficulties attending on which being of such a nature that they might well militate against the efficiency of the bucket as a sampler. There are moreover objections against most types of draw buckets ordinarily in use on the grounds of cleanliness.

It is considered that the use of the surface sampler would materially improve the collection of samples for salinity determination and that so far as observation of temperature is concerned, given ordinarily advantageous conditions, with due precaution readings may be obtained with a fair degree of accuracy.

The apparatus, which is made in brass, consists essentially of two parts — head and body. The body is formed of a brass tube *A* (see Figure 1), having a base plate *B* to which is attached a cup *C* by means of a nut *H*. The sample bottle *G* (capacity about 150 cc.) is supported on the plate *D*, and when the apparatus is assembled maintains the spiral spring *E* in compression. The movement of plate *D* in the cup *C* is determined by the guide screws *FF'*. The base plate *B* carries an eyebolt *J* to which a preventer wire *K* may be fastened as an additional safeguard against loss should the spring catch *T* fail to prevent the head rotating and so coming apart from the body.

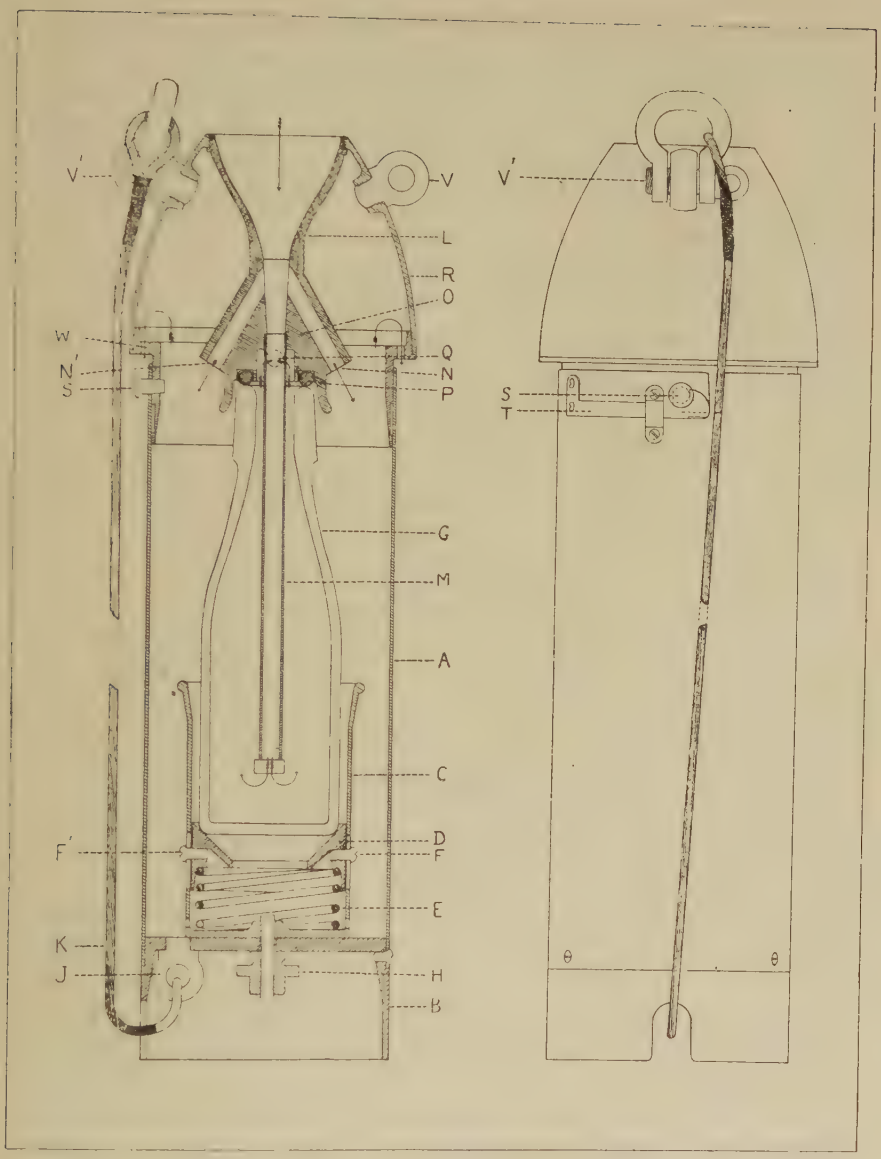

Fig. 1.

The outer shell R of the head carries at its upper end a funnel piece L which is continued in the tube M, passing well down into the sample bottle. A casting O, between the funnel piece L and the tube M, carries two side tubes NN', which assist in promoting the circulation of water within the cavity of the body. The casting O also furnishes a bed for

the rubber washer P against which the head of the sample bottle G bears, and in this casting are the outlet ports Q from the sample bottle.

The lower end of the outer shell R is a loose fit in the body tube A. The head is held to the body by 3 lugs on the head fitting into grooves in the body tube, forming 3 bayonet joints. A spring catch T operates with one of the lugs to prevent the head rotating in the body, and so becoming free from it.

Towing bridles are shackled to the two eyebolts VV' screwed into the head of the apparatus. The towing line consists of a length of $1^1/_2$ inch circumference manila rope (usually of about 10 fathoms length), having an eye at one end, to which is shackled a swivel; to the other

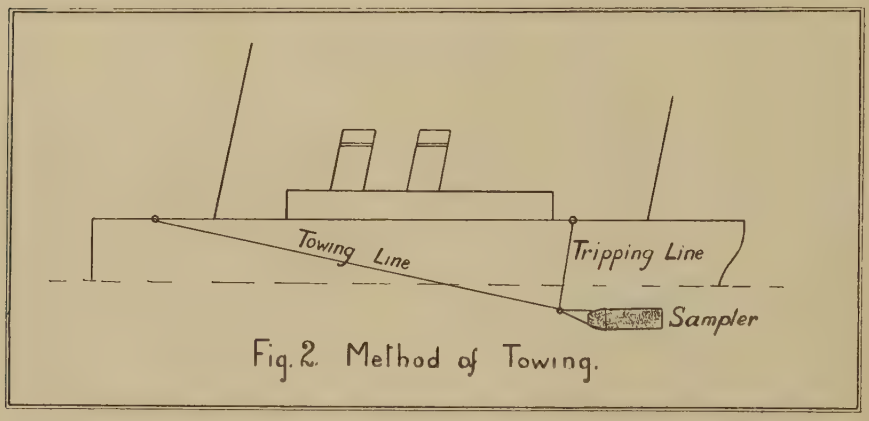

Fig. 2. Method of Towing.

end of the swivel two bridles (each about 3 feet of $^1/_4$ inch circumference wire rope) are shackled and the other ends of these bridles are shackled to the eye bolts VV'.

Figure 2 illustrates a convenient method of towing.

When the apparatus is towed, water enters the apparatus through the funnel piece L; part of the water is diverted through the side tubes NN' into the body cavity, and part flows through the tube M into the sample bottle where it passes through the outlets Q into the body cavity of the apparatus. The water leaves the apparatus through a series of ports W on the under side of the head.

The spring cup C can be removed for cleaning etc. by unscrewing the nut H. Removal of the guide screws FF' gives access to the spring E. The tube M is also easily removable for cleaning. The weight of the apparatus assembled and filled, but excluding bridles and towing line is about 7 kilos.

In order to test the efficiency of rinsing, a sample bottle and the body cavity of the apparatus were filled with a coloured liquid and towed for various periods at speeds from about 8 to 25 knots. After towing for 5 minutes no trace of colour was visible in the sample brought in, and at high speeds this was also the case when crystals of potassium permanganate were placed in the sample bottle. The period for which it is necessary to tow the apparatus consistent with efficient washing must naturally vary with the speed of towing, and this period can readily be ascertained by making similar tests to that outlined above.

One of these samplers has now been in use for more than a year in s.s. "Dieppe" Southern and French State Railway Co., and, so far as its operation is concerned, has proved satisfactory.

When samples for salinity determination are collected in an ordinary bucket, attention must be paid to the cleanliness both of the draw bucket itself and of the bottle in which the sample is to be stored. Instructions are given to Observers in which they are asked to take 2 or 3 successive casts of the bucket well forward from any waste discharges before bringing on board a final sample. This procedure may sometimes be inadequate or neglected, since samples are ocassionally received which contain foreign matter of a nature suggesting a dirty bucket as origin. Moreover, though the sample bottles are, through the kindness of the Government Chemist, carefully cleaned and inspected at the Government Laboratory before being despatched to the various ships, it seems that it is possible for contamination to arise through salt dust particles entering the bottles after packing (*vide* J. R. Lumby, Fishery Investigations, Ser. II Vol. VII, No. 7. 1924 (1925), appendix p. 22). Rinsing the bottle with some of the sample should indeed be sufficient to remove contamination of this type, but neglect of this precaution might conceivably introduce errors larger than permissible.

The surface sampler was primarily designed to minimise such errors, and with this apparatus the salinity sample is collected in the bottle in which it is to be stored, and this bottle is washed automatically in the process of collection.

As regards the observation of temperature the surface sampler provides a sample for temperature determination separate from that destined for salinity determination. With the apparatus in its present form the volume of the sample available for temperature determination is approximately 1 litre.

Surface temperatures from light vessels and commercial ships are commonly given to the nearest 0.1° C., but it is questionable whether an accuracy of $\pm$ 0.05° C. is always obtained, in support of which the

following observation may be cited from the Bulletin Trimestriel No. 1 1927:—

15/I/1927, 57° 49½ N. 22°38′ E., — 2.0° C., 6.20 ‰; the freezing point of water of that salinity being —0.3° C.

In order to obtain the highest possible accuracy when no thermal insulation of the sample is provided, it is necessary that the bucket — or whatever may be used for drawing the sample — should remain submerged for a time sufficient to allow the bucket to reach the same temperature as the water. Then, to ensure that the temperature of the sample is observed as soon as possible after the sample is drawn, the draw bucket must be convenient to handle, while at the same time the volume of the sample must be large enough to preclude too rapid changes of temperature through exchange of heat with the atmosphere. Moreover, precaution must be taken against cooling through evaporation, either from the sample itself or from the surface of its container, and finally the thermometer used must be sensitive and of low thermal capacity. The thermometer moreover ought to be at the same temperature as the water sample, and to this end should be included in the apparatus, though provision for such an arrangement is not made in the present design of the surface sampler.

In order to furnish an idea of the relative efficiency of the various types of buckets commonly in use, in regard to the accuracy with which it is possible to obtain observations of surface temperature, iron, leather and canvas buckets were immersed, together with a surface sampler fully assembled, in the sea from the side of the ship at anchor away from direct sunlight for a period of at least ten minutes. Each drawbucket was removed in turn, placed on a grating on deck out of direct sunlight and the temperature of the sample determined at successive intervals. From these observations the rate of change of temperature was estimated roughly by plotting temperature against time and drawing a freehand curve through the points. These results are shown in Table 1, series A. Series B and C relate to similar experiments made on shore, the samplers (without heads) being first immersed in a tank and then placed on a ledge before an open window, away from direct sunlight. In these two latter experiments the thermometer was placed in the sampler before immersion, so that it should not be necessary to wait until the thermometer had reached the temperature of the sample before a reading could be obtained. As an attempt to increase the insulating properties of the surface samplers a sheet of $^1/_{16}$″ rubber was bound round the body of sampler No. 3, but this device does not

Table I. Showing the rate of change of temperature of water samples under different conditions of collection.

(1) Series	(2) Apparatus	(3) Approx. Capacity	(4) Air Temp. Wet bulb.	(5) Air Temp. Dry bulb.	(6) Air Temp. Diff. (5—4)	(7) Water Temp. (estim.)	(8) Diff. (4—5)	(9) First obsn. of temp. of Sample	(10) Time of first obsn.	(11) Diff. (7—9)	(12) Average Rate of change of temp. (of sample) per min. over first 2 mins.
		litres	°C.	°C.	°C.	°C.	°C.	°C.	m. s.	°C.	°C./min.
A.	Iron bucket	8	13.79	15.23	+1.44	13.80[1]) (14.03)	—1.43[1]) (—1.20)	13.82[1]) (13.92)	2.33[1]) (0.45)	—0.02[1]) (+0.11)	+0.01[1]) (—0.10)
	Canvas bucket	1½	..	..	..	13.80	—1.43	13.81	0.40	—0.01	+0.01
	Leather bucket	8	..	..	..	13.77	—1.46	13.78	0.50	—0.01	+0.00
	Sampler No. 2	1	..	..	..	13.81	—1.42	13.83	0.55	—0.02	+0.02
						13.89	—1.34	13.90	0.20	—0.01	+0.02
B.	Sampler No. 3 (lagged)	1	17.65	19.91	+2.26	22.10	+2.19	21.99	0.25	+0.11	—0.13
	Sample No. 4 (no lagging)	1	..	..	..	22.13	+2.22	22.10	0.15	+0.03	—0.16
	Canvas bucket	1½	..	..	..	22.06	+2.15	22.01	0.18	+0.05	—0.07
C.	Sampler No. 3 (lagged)	1	17.24	19.51	+2.27	23.81	+4.30	23.70	0.32	+0.11	—0.21
			17.09	19.60	+2.51	23.58	+3.98	23.50	0.16	+0.08	—0.20
	Sampler No. 4 (no lagging)	1	17.10	19.51	+2.41	23.77	+4.26	23.69	0.18	+0.08	—0.21
			16.81	19.40	+2.59	23.50	+4.10	23.40	0.22	+0.10	—0.20
	Canvas bucket	1½	17.10	19.85	+2.75	23.64	+3.79	23.60	0.15	+0.04	—0.12
			16.78	19.27	+2.49	23.39	+4.12	23.32	0.20	+0.07	—0.11

[1]) Neglecting observations made in first 2½ minutes, the figures in brackets below being the values obtained according to the normal procedure.

seem to have produced an appreciable improvement under the conditions then existing.

Columns 4 and 5 give the readings of wet and dry-bulb thermometers placed in the neighbourhood of the draw buckets during the time the observations were in progress. For series A and B are given averages of a number of readings taken during the course of the experiment.

Column 6 gives the differences between these readings, giving a measure of the rate of evaporation.

Column 7 gives the temperatures of the waters from which the samples were drawn, as extrapolated from the graphs mentioned above.

Column 8 gives the differences between air and water temperatures (estimated) at the times of the experiments.

Columns 9 and 10 give the first observations made of the temperature of the samples and the times at which they were made, times being reckoned from the withdrawal of the buckets from the sea or from the tank.

The differences between these first observations of temperature and the estimated water temperatures are given in Column 11.

Column 12 gives approximations to the average rates at which the temperatures of the samples changed in degrees centigrade per minute reckoned over the first 2 minutes. In the first place it is evident, as is to be expected, that, as regards the different series the rate of change of temperature increases as the difference between air and water temperature increases In series A the temperature of the samples in the canvas and leather buckets changed less rapidly than that of the samples in the iron bucket and in the surface sampler. With an air temperature 1.4° C. above water temperature, and a wet- and dry-bulb difference of 1.4° C., 5 minutes could have elapsed after drawing the sample before the temperature of the sample in surface sampler No. 2 would have changed by 0.1° C., a time limit which makes it reasonable to suppose that an accuracy of $\pm$ 0.05° C. could have been obtained under the conditions prevailing.

It was at first thought that the low rate in the case of the canvas bucket might be ascribed to the fact that loss of heat through evaporation from the wet surface of the bucket was almost balanced by the gain of heat from the air, but in series B and C when water temperature was higher than that of the air, and the loss of heat due to evaporation would tend to increase the cooling rate, this rate was, for the canvas bucket, again lower than that for the two samplers.

Returning to series A, at first the temperature readings for the sample in the iron bucket, the first to be drawn from the sea, fell from 13.92°

to 13.82° C., afterwards rising at the rate of ca. 0.01° C. per minute. It is thought that this initial fall may have appeared from the fact that the thermometer, which was at a temperature higher than that of the water, required from 2 to $2^1/_2$ minutes in which to become adjusted to the water temperature. This time appears to be unduly long, but unfortunately the thermometer used, which was of a special type and of which no duplicate is at present available, has subsequently been broken, and the point cannot be checked.

In series B and C, with air-water temperature differences of about 2° and 4° C. respectively, the rates of temperature change were roughly 7 and 11 times the rates found for the sampler used at sea (series A). That is to say, in order that observed water temperatures should not differ by more than 0.1° C. from true temperatures, readings must be obtained under these conditions in less than $^3/_4$ min. and $^1/_2$ min. respectively after drawing the samples. Though it is possible to obtain an observation in less than 1 minute after collection, it would not be justifiable to expect an accuracy to the nearest 0.1° C. under the conditions of series C, and even under the conditions of series B this accuracy could not be assumed with certainty.

It therefore appears that as regards temperature observations, the surface sampler, though it may be modified with advantage, can be used with due precaution in ordinarily favourable circumstances so as to yield observations which may be relied upon to differ from the true temperatures by not more than $^1/_4$° C. Lagging with sheet rubber having so far proved ineffective, it is possible that improvement may be made by increasing the capacity of the apparatus and/or by fitting an insulation jacket, and further it is hoped that some method may be found for including the thermometer in the apparatus.

It has been suggested by Professor Otto Pettersson that sea temperatures might be obtained from the inlet pipe to the condensers in commercial ships. While it is an advantage that in many ships observation of the inlet water temperature is a matter of routine, and that accurate readings would probably be readily obtainable, such observations are not necessarily comparable with surface samples taken from on deck, since the inlet pipe is necessarily below surface, and moreover its depth varies from ship to ship and in the same ship according to circumstances. Surface temperatures taken from on deck relate perhaps to the uppermost metre of water. In the southern part of the North Sea it is sometimes possible to obtain a value from 30 or 40 metres depth which would not differ appreciably from an observation taken at the surface of the same water column, though on a hot calm day a very thin layer might be

formed having a very high temperature which would be rapidly dissipated with the advent of wind. Again a high degree of vertical homogeneity is attained in winter in the northern North Sea, such that in a vertical series down to 80 metres no differences greater than 0.01° C. might be found, but in summer near the coast an observation at 10 metres might differ from one at 0 metres by more than 1° C.

Through the courtesy of the Marine Superintendent of the Meteorological Office, London, data from R.M.S. "Majestic" (Commodore Sir Bertram Hayes) have been furnished relating to air and sea temperatures, the latter being taken (a) by using a draw bucket from on deck and (b) from the main injection pipe 30 feet (9 metres) below the surface, at 4-hourly intervals on passage from Southampton to New York and on the return voyage. These observations were made between 4 p.m. 15th/XI/1923 and 4 p.m. 29th/XI/1923. In addition, Captain S. Marmery, s.s. "Dieppe", Southern and French State Railway Co., has kindly furnished similar data, giving daily observations (at midnight?) during the month of November 1926 from the English Channel, at position (approx.) 50°23′ N. 1°29′ E. In this case the depth of the inlet pipe was 10 feet (3 metres) below the surface.

These observations which were recorded in degrees Fahrenheit, are summarised in Tables 2 and 3.

In regard to the observations from s.s. "Dieppe" in only one case is a difference of 2° F. recorded between two corresponding water temperature observations and the averages for the month differ by 0.1° F.,

Table II. Showing the Temperature of the Air and of the Sea (a) as observed by using a draw-bucket and (b) as taken from the inlet pipe.

Ship	Depth of Inlet pipe	No. of observations	Time	Averages		
				Air Temp.	Water Temp.	
					by draw bucket	from inlet pipe
	m.			° Fahr.	° Fahr.	° Fahr.
S.S. "Dieppe".....	3	30	—	49.5	55.2	55.3
R.M.S. "Majestic".	9	60	All	54.9	56.1	55.9
			4 a.m.	53.9	54.5	55.5
			8 a.m.	55.6	58.7	58.8
			noon	56.8	56.7	56.5
			4 p.m.	54.2	55.9	56.3
			8 p.m.	54.2	56.0	55.4
			m'dn't	54.5	54.7	53.1

Table III. Showing the Number of Occurrences of Differences between Observations of Sea-temperature as made (a) by using a draw-bucket, and (b) from the inlet pipe.

Ship	Difference ° Fahr.	Number of Occurrences		
		+ *ve*[1])	— *ve*	Total
s.s. "Dieppe"	0	16		16
	1	6	7	13
	2	—	1	1
				30
R.M.S. "Majestic"	0	6		6
	1	2	5	7
	2	11	2	13
	3	3	1	4
	4	7	9	16
	5	—	2	2
	6	1	1	2
	7	1	2	3
	8	2	1	3
	9	1	2	3
	10	—	—	—
	11	—	—	—
	12	—	—	—
	13	—	—	—
	14	1	—	1
				60

so that in these circumstances one might be justified in regarding the inlet temperature observations as comparable with surface observations proper.

The two sets of observations from R.M.S. "Majestic", however, show considerably greater differences, the most frequent being 4° and 2° F. respectively, and though the averages for the whole period differ from one another by only 0.2° F., 57 per cent. of the observations exhibit differences of 3° F. and above. It may therefore be concluded that the method of observing the sea temperature at the inlet pipe cannot at present replace the existing procedure for surface observations, though the collection of inlet temperature observations as representative of sub-surface conditions might well prove a valuable addition to hydrographic work.

[1]) A + *ve* value indicates that the temperature observation made by using a draw-bucket was higher than that obtained from the inlet pipe.

In conclusion, I wish to offer my thanks to Mr. D. J. Matthews, Hydrographic Department, the Admiralty, London, for giving me the benefit of his experiences with a similar type of apparatus; to Mr. Harry J. Garrood of Messrs. Elliott & Garrood, Ltd., Beccles, Suffolk, whose help in drawing up the technical details of the design has been invaluable; and to Captain S. Marmery and Mr. Shaw, Chief Officer, s.s. "Dieppe" for their very kind assistance during tests of the apparatus. I am further indebted to Messrs. Elliott & Garrood, who have constructed the surface samplers now in use, for the print from which Figure 1 was prepared; and to Mr. Stokes, of the Laboratory staff, for preparing the diagrams for publication.

On the selective Action of a Trawl Net, with some Remarks on selective Action of Drift Nets.

By

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The present paper makes an attempt at rigorous and methodical treatment of data relating to selection by a trawl net, and one of its objects is the obtaining of statistical constants and curves corresponding to those employed in the usual treatment of frequency distributions. Another object of this paper is to provide a standard method not only of describing the kind of selection exercised by a particular net, but of applying our data to the derivation of the character over a certain size range of the stock of fish on the ground from which the selected specimens were obtained. This is desirable in all trawling investigations.

Firstly it is necessary to make a working definition, namely that of "Chance Selection" corresponding to the term "Chance Variation" which is used to define variation coming under the Law of Error. Chance Selection may be defined then as selection, variations in which are due to a multitude of small causes, each equally likely to be positive or negative, and no cause or causes being preponderant. The meaning of this definition will become clearer after the argument has been further developed. For the present it should be noted that the method here proposed deals only with Chance Selection. Variations in Chance Selection as applied to selection by a net, may be due to differing size of fish, differing size of meshes, or stretching or laxity of meshes above the normal. Such variations as are due to biassed conditions, for instance to the blocking of meshes by a very large catch of fish or weed, to the extra power of large fish to escape, to tears in the net &c., cannot be considered in the general theory. The theory is thus applicable only to smallish catches made on fairly clean ground, but it may prove useful in treating other data if only by showing the existence of biassed causes of variation.

Consider now the chance of a fish being retained in the codend of the trawl. There is no absolute certainty either of escape or capture whatever the size of the fish or mesh. Thus at any size of fish x, P, the probability of capture has a positive fractional value. As x increases P increases, but P never becomes equal to I. On a little thought, however, it becomes obvious that $\overset{\times}{P}$, the rate of increase of P with increase of x, increases up to a certain point, and then falls again. $\overset{\times}{P}$ would appear to reach a maximum at about the point where there is an even chance of the fish's escaping, for since P never equals 0 and never equals I, the curve having values of P as ordinates has the lines $P = 0$ and $P = I$ as asymptotes. If $\overset{\times}{P}$ is greatest at exactly the point $P = {}^1/_2$, we have what may be termed Normal or Symmetrical Selection. Where $\overset{\times}{P}$ is greatest at some other value of P, we have Skew Selection. We have, therefore, for P, x being size of fish, a curve starting at what for the present we may call the point $x = 0$, $P = 0$, having a point of inflection at $x = n$, $P = {}^1/_2$ and approaching asymptotically the line $P = 1$. The known characters of the curve, therefore, resemble very closely those of the ogive of the Curve of Error, though it cannot for the present be assumed that the curve is actually of that form. Similarly the curve for $\overset{\times}{P}$ resembles in character the Curve of Error itself, for at very small sizes of fish there is practically no increase in the catching power of a net with increase in size of fish, and the same argument holds for sizes of fish all of which are too large to go through the meshes. Thus somewhere in between there is a size when the increase in catching power for increase of size of fish is a maximum. Also unless selection is absolute the variation in rate of change of catching power must be a gradual and continuous one. By "absolute selection" I mean such selection that all fish below a certain size "a" escape, while all fish above that size are retained. Exactly at the size "a" the fish will fit the meshes, P, the chance of capture $= {}^1/_2$, and obviously $\overset{\times}{P}$, in "absolute selection" is at a maximum when $P = {}^1/_2$, because they would all be retained at $a + da$ and none at $a - da$. Thus it is seen that Normal Selection is what may be termed a symmetrical expansion of absolute selection.

Now if we consider the stock instance of the Error Distribution, namely that of shots on a target, we shall see that there are obvious analogies between that case and the case of the selective action of a net.

In Fig. 1, we have a target consisting of a steel knife edge AB. The bullets are for the moment assumed to be flying dead true, and there are no small variable causes tending to throw the bullets out of line. AB is assumed to be movable across the line of fire. One side of

the background of the target is labelled "escape", the other side "capture". If now the edge AB is exactly in the line of fire, the bullets will be cut in half (chance of "capture" $P = .5$). If AB is out of the line of fire, all the bullets will fall either into "capture" or "escape".

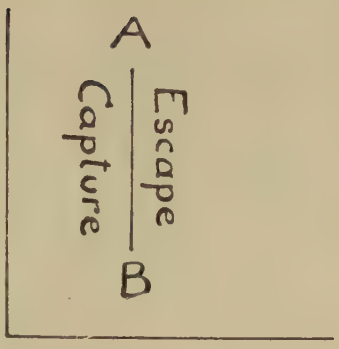


Fig. 1

This is the case corresponding to "absolute selection". Moving AB to the right corresponds to increase of size of fish or decrease of size of mesh, or to variation to a known amount of any small cause tending to increase capture of a fish.

In Fig. 2, AB is the knife-edge target as before, but now the usual small causes producing shot-distributions are supposed to be in action. A fair shot is firing, and he has estimated his average wind correctly &c. but is somewhat uncertain, the wind is gusty, the ammunition unreliable &c. Considering horizontal distribution of bullet-holes, the result given as a frequency curve would resemble the curve (i) given in Fig. 2, that is to say the Curve of Error.

Now this case is obviously analogous to the case of selective action of a net on such a size of fish that on the average half escape and half are retained. Next assume variation to a known amount of one of the contributory small causes of the bullet-distribution, for instance increase the left throw of the rifle to the extent of 2 inches at the range used. The whole distribution will then move 2 inches to the left, the area (no. of shots) and σ of the curve being the same as before. See Curve (ii), Fig. 2.

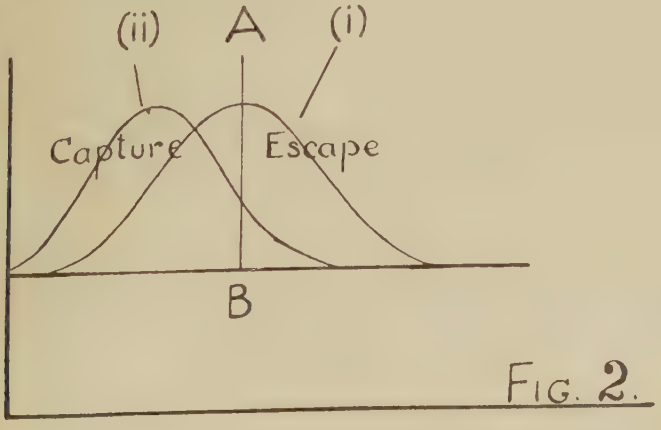
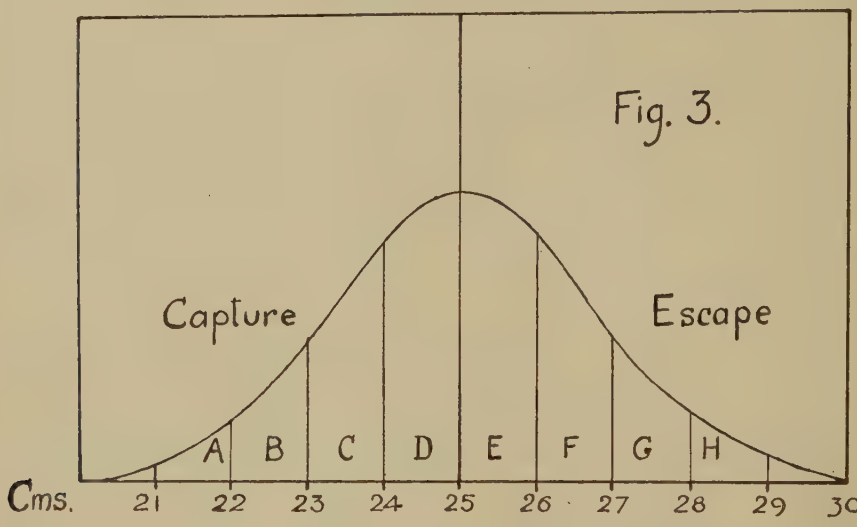


Fig. 2.

Applying the argument to the net question, suppose 25 cms. to be the size at which fish of a certain species are found half in the codend and half in the cover. Then, if the theory holds good, varying the size of a fish or a mesh to a given amount will correspond to varying the left throw of a rifle in the former argument. The ordinates of a curve such as that given in Fig. 3 would give the proportionate chances of a fish of any given size to fit a mesh. The areas A, $A + B$, $A + B + C$ and so on under the curve between 0 cm. and any size gives the chance of a fish of that size being captured. What is the same thing, this area, or P, gives the proportion of the fish of that size entering the codend,



which are retained. The theory that selection comes under the Law of Error is of course something of an assumption, but it does seem reasonable to assume the probability that it does so since the conditions of contributory causation are similar. The value of the theory depends of course on whether it is found to fit the data obtainable, and therefore we will proceed to consider its application to such data, which may consist of results from various covered-net experiments made in the International Sea Fisheries Investigations &c.

Application of the Theory. It is of little use to test the method at first on data that appear very irregular. Todd[1]) gives tables of percentages of various species of fish retained by different parts of a trawl, as determined by the number passing through into fine-meshed covering

[1]) R. A. Todd: Covered Net Experiments. Intl. Invs. Mar. Biol. Assoc. Report III (Cd. 5546. Pub. 1911).

nets. The important part of the curve representing selection of a net is that part bordering on the 50 per cent. selection point; and it is little use attempting to fit a curve to data which are entirely irregular at or near this point. Among others a set of data for Haddock given on Page 200 of Todd's Report[1]) would appear to be amenable to treatment. The first two columns of the following table give the percentages of Haddock at each cm. length retained in this particular experiment in the codend of the otter trawl, taken to the point where all are retained.

(1) Cms.	(2) % retained	(3) Diffs	(4) Logs of (3) y	(5) x	(6) xy	(7) x^2	(8) x^2y	(9) x^4	(10) x^4y	(11) Graduated Logs	(12) Antilogs or Graduated Σ curves
13	67		..	..	..	..	..	..	..	..	..
14	57		..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..	..	..
16	7	7	..	..	..	..	..	..	..	..	..
17	19	12	..	..	..	..	..	..	..	..	..
18	32	*13	1.1139	—2	—2.2278	4	4.4556	16	17.8224	1.0805	12.03
19	55	*23	1.3617	—1	—1.3617	1	1.3617	1	1.3617	1.41287	25.87
20	82	*27	1.4314	0	0	0	0	0	0	1.4219	26.42
21	95	*13	1.1139	+1	1.1139	1	1.1139	1	1.1139	1.09859	12.56
22	98	*3	0.4771	+2	0.9542	4	1.9084	16	7.6336	0.47294	2.971
23	100	2	..	..	..	..	..	..	..	..	..
		Σ marked terms = 79	Σy = 5.498		$\Sigma(xy)$ = — 1.5214	$\Sigma(x^2)$ = 10	$\Sigma(x^2y)$ = 8.7396	$\Sigma(x^4)$ = 34	$\Sigma(x^4y)$ = 27.9316		Σ = 79.85

The third column gives the proportionate chances of fish between certain sizes sticking in a mesh, or hitting the 50 per cent. selection point. It will very rarely be found possible to adapt the theory of Chance Selection to include the end points of data. Thus, in the present case, the data for fish of 13 and 14 cm.s obviously do not come under the same law of selection as the larger fish. We must thus find some method of fitting the Curve of Error to the points bordering on the *mode* of the curve of differences. It is proposed here to fit, by the Method of Least Squares, a parabola of the form $y = a + bx + cx^2$ to the *togarithms* of the more central differences given in column 3 of the table. The antilogarithms will then lie on a Curve of Error. A curve obtained by the Method of Least Squares conforms to the requirement that the

[1]) R. A. Todd: Covered Net Experiments. Intl. Invs. Mar. Biol. Assoc. Report III (Cd. 5546. Pub. 1911).

sum of the squares of the differences between the data and the corresponding points on the curve is as small as possible. In the Curve of Error obtained as above, however, the sum of the squares of the proportional, not actual, differences, is as small as possible. A difference between ordinates of value 100 on the curve and of value 50 in the data is thus considered to be the same as the difference between ordinates of values "2" and "1" on curve and in data. This may be an objectionable point in the method, but it is thought that, if the ordinates chosen from the data are equally reliable, the fitting of a curve on the above assumption is advantageous. Its effect is to make the curve pass nearer to the lower points chosen than to the higher, which is probably an advantage if it is intended to complete the curve, continuing it through points corresponding to data not chosen for deriving it.

By the Method of Least Squares

$$\frac{\delta}{\delta a} \Sigma\,(a+bx+cx^2-y)^2 = 0$$

$$\frac{\delta}{\delta b} \Sigma\,(a+bx+cx^2-y)^2 = 0$$

$$\frac{\delta}{\delta c} \Sigma\,(a+bx+cx^2-y)^2 = 0$$

Thus

$$\Sigma\,(a+\underline{bx}+cx^2-y) = 0 \qquad (1)$$

$$\Sigma x\,(\underline{a}+\underline{bx}+\underline{cx^2}-y) = 0 \qquad (2)$$

$$\Sigma x^2\,(a+\underline{bx}+cx^2-y) = 0 \qquad (3)$$

Now, by taking the origin of the curve at a central ordinate, say the centre of a group of five, the sums of multiples of odd powers of x vanish, and work is much simplified. The vanishing terms in above equations are underlined. We have then, if n be number of ordinates (in the present case 5)

$$\Sigma a = na$$

$$na + \Sigma(x^2)c = \Sigma y$$

$$b\Sigma(x^2) = \Sigma(xy)$$

$$a\Sigma(x^2) + c\Sigma(x^4) = \Sigma(x^2y)$$

$$\therefore\ b = \frac{\Sigma xy}{\Sigma x^2}$$

$$a = \frac{\Sigma(x^4)\Sigma y - \Sigma(x^2)\,\Sigma(x^2y)}{n\cdot\Sigma(x^4) - [\Sigma(x)^2]^2}$$

$$c = \frac{n\Sigma(x^2y) - \Sigma y\cdot\Sigma(x^2)}{n\cdot\Sigma(x^4) - [\Sigma(x^2)]^2}$$

With 5 ordinates

$$\Sigma(x^2) = 10, \quad \Sigma(x^4) = 34$$

With 3 ordinates

$$\Sigma(x^2) = 2$$
$$\Sigma(x^4) = 2$$

With an even number of ordinates, the origin may be taken between the middle pair, the values of x for ordinates being $^1/_2$, $1^1/_2$, $-^1/_2$, $-1^1/_2$, and so on.

For 4 ordinates

$$\Sigma(x^2) = 5, \quad \Sigma(x^4) = 10.25$$

Thus the equations for fitting the most suitable curve to the logarithms of the numbers in tables such as that given above are extremely simple, it being necessary merely to multiply up the "frequencies" by powers of x, as has been done in the table. The ordinates chosen are marked with a cross.

Thus in the equation: $-y = a + bx + cx^2$ .....(A)

$$b = -.15214,$$
$$a = 1.4219,$$
$$c = -.16117$$

The equation is therefore for the logarithms

$$y = 1.4219 - .15214x - .16117x^2 \ldots\ldots\ldots\ldots \text{(B)}$$

Graduated figs for logs and antilogs are given in the last two columns of the table.

To find the mode put

$$\frac{d}{dx}(a + bx + cx^2) = 0$$
$$\therefore b + 2cx = 0$$
$$x = \frac{-b}{2c}$$

Mode is therefore at

$$20 - .472 = 19.528$$

The equation for the Curve of Error corresponding to (A), the exponential terms being multiplied by 2.3026 to reduce them to Natural Logarithms, is

$$Y = e^{3\cdot275 - \cdot3502x - \cdot3712x^2} \ldots\ldots\ldots\ldots \text{(C)}$$

The equation (A) may be written:

$$y = \left(a - \frac{b^2}{4c}\right) + c\left(x - \frac{b}{2c}\right)^2$$

and the corresponding Curve of Error thus

$$Y = e^{\left(a - \frac{b^2}{4c}\right) + c\left(x - \frac{b}{2c}\right)^2}$$

Thus $Y_0 = e^{\left(a - \frac{b^2}{4c}\right)}$ and changing the origin to the mode, that is, putting X for $\left(x - \frac{b}{2c}\right)$ we have

$$Y = Y_0 e^{cX^2}$$

The Standard Deviation, σ, is given by

$$\sigma = \sqrt{\frac{1}{2c}} = \pm 1{\cdot}161$$

$$Y_0 \text{ is antilog } a - \frac{b^2}{4c} = 28{\cdot}72$$

The area of above curve

$$= Y_0 \int_{-\infty}^{\infty} e^{cX^2} \cdot dX = Y_0 x \sqrt{\frac{\pi}{c}} = 83{\cdot}56$$

By the theory of Chance Selection the above area should be equal to a hundred, since it is an expansion of the area representing "absolute selection", which entails certainty of 100 fish of a certain size exactly fitting the mesh and no chance at all of fish of any other size fitting the mesh. The ordinate or Y_0 here is infinite and $\sigma = 0$. In assuming that Chance Selection is an expansion of this condition we are assuming that all the "difference areas" are different parts of the area of the same curve. Thus, even on theoretical grounds an exact correspondence between the total calculated area and the theoretical area for the difference curve is hardly to be expected. When it is considered that the empirical curve is fitted to a few points only of the series of observed differences, it is surprising that the total areas only disagree by 16 per cent. The "total area fit" may be improved in the example given, by including the frequency 12 at 16—17 cms. but the agreement in ordinates is not so good in this case. The agreement in total of calculated and observed differences over the range considered (17 to 22 cms.) is remarkably good. The object of this paper is, however, the introduction of a practical method of viewing and treating problems of selection by nets, and it is not thought that the theory expounded here is in exact agreement with the true theory.

Fig. 4 shows the Curve of Error deduced from the equation (C). The crosses are points on the Curve of Error while the dots give the position of the original numbers selected for treatment. It would seem therefore that in the case taken the theory expounded in this paper fits well enough for practical purposes. There can be no doubt whatever that the use of the Theory of Error in dealing with selection rests on a far sounder basis than its use in frequency distributions and even in these it has proved of much service, but it must be emphasized that it is only within the range of sizes where selection is a function of the mesh that the theory as used above may be expected to hold approximately. On examining Todd's table from which our figures were selected it will be seen that very large percentages of very small fish were taken. The selection of these is obviously not a function of the mesh but of quite other conditions. Among such may be high mortality among small fish, or large catches of weed. At the upper end of the ogive curves also many irregularities occur. Thus the size at which all the fish are retained is very indefinite. At both ends of the curve of differences, negative ordinates frequently occur. These cannot possibly be due to selection by the mesh, it being obvious that increase of size of fish must increase probability of capture if the selectiveness of the mesh has free play.

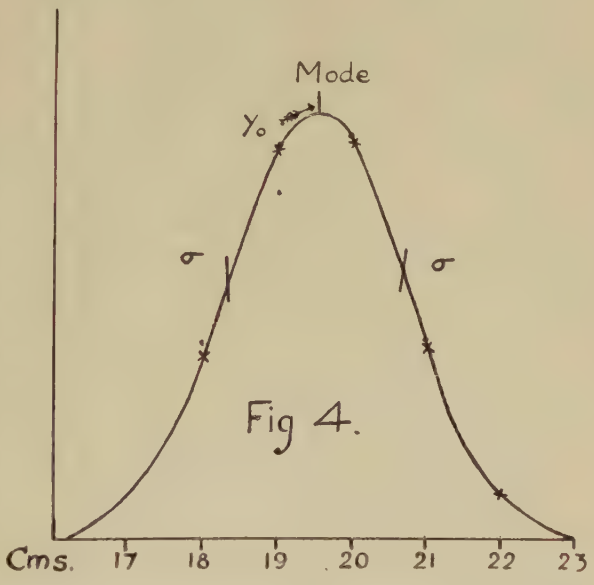
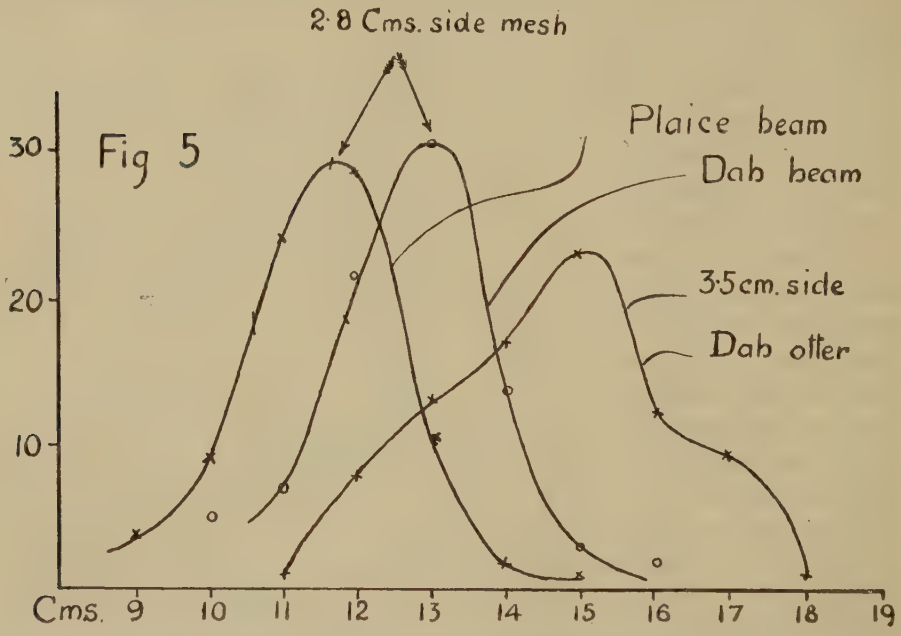


Fig 4.

A few central ordinates of the difference curves nearly always show a fair amount of regularity; they demonstrate the law of the mesh, and it is claimed that the extension of the law on either side of the regular ordinates gives a far truer picture of the effect of the mesh on various sizes of fish than even the actual data obtained from trawl-catches. Apart from this consideration, convenient constants are obtained by the present method for comparison between various meshes. Of such are the Modes and Standard Deviations of the difference curves.

It may very likely be found that the Standard Deviations are functions of the size of mesh or of its shape. Applicability of the theory to Experiments with the "trouser trawl" depends on the proportionate sizes of the meshes in the two "legs". If the meshes in one leg are small enough to retain all the fish of which say 80 per cent. are allowed to escape by the other leg, the present theory may be directly applied. If these conditions do not exist, however, it is not possible to obtain the necessary central ordinates of the difference curve for the larger leg, since the theory demands that the numbers of fish of the said central sizes retained



are known as a proportion of the numbers of fish of those sizes entering the codend.

Fig. 5 gives three difference curves of other selection data taken from Todd's paper. The curves are drawn freehand through the difference values. The two curves for the beam-trawl appear to be very similar to curves of error, and it is probable that within the range covered by the curves, selection by the mesh is having free play. The curve for otter-trawl selection of Dabs is very irregular, and it would seem that here selection by the mesh is cloaked by other causes.

The difference in position between the modes in the Dab and Plaice curves respectively are probably caused by difference in the shape of the fish. The Standard Deviations or spreads of the two curves would

appear to be about the same. On reference to Todd's figures (Page 198 loc. cit.) it is seen that the modes of the difference curves are quite independent of the modes of the fish populations sampled, which is evidence that selection by mesh is having fairly free play within the range considered. The difference curves for Whiting both for beam-trawl and otter-trawl are quite irregular, and it is obvious that for these fish no orderly selection by the mesh obtains; the high mortality in these fish may account for this fact.

In conclusion it should be emphasized that the raison d'être of this paper is the writer's opinion that at the present juncture, when consideration of the regulation of the mesh-sizes in fishing gear is much to the fore, anything is of value which may possibly help to disentangle the actual effects of mesh sizes on sizes of fish caught, from the mass of small biassed causes affecting catches by nets.

On Selection by Drift Net.

The application of the Theory of Chance Selection to the question of selection by a drift net offers many difficulties. Thus it is not possible accurately to obtain the frequency distribution of the fish meeting the net and exposed to risk of capture, by any imaginable means. It is worth while, however, considering the manner of action of a drift net and estimating the probable effect of selection thereby on a hypothetical frequency group. Since the meshes in a drift net are held wide open by reason of the way in which the net is supported, it is most probable that the selectiveness of the mesh has far freer play than in the case of a trawl net, so that the Chance Theory, adapted to fit the peculiarities of the case, may be expected to hold good in a high degree.

In the case of a trawl net each curve of differences of which the ordinates represent the proportionate chance of a fish of size x "fitting" a mesh may be divided into two parts, representing escaping and captured fish. This cannot be done in the case of a drift catch. The captured at each size ($x^n - x^{n-1}$) are more nearly represented by the portion of the area of the curve between the corresponding ordinates. If the "catchableness" of a fish were a quantity continuously increasing with size of fish the said areas would probably represent proportions caught very fairly. It is fairly obvious, however, that "catchableness" is not a continous function of size, but has certainly two points of discontinuity, one caused by the presence of gill covers coupled with the greater hardness of the head than the body, the other by the presence of the two angles of the maxillae, which form a kind of barb. The effect of these two

"barbed" points and particularly of the latter mentioned is undoubtedly to produce multimodal selection. Fish larger than the general run of fish in the net are often caught "by the nose", that is to say, by the maxillary barbs. They drop out very easily, but many of them are landed by the nets being turned so that the fish are on the upper side. Behind the maxillary "barb" there are sections of gradually increasing periphery which offer no hold for the mesh, and it is probable that fish smaller than those caught at the barbs and small enough for these sloping sections to strike the net have very little chance of being captured. Fish of still smaller size will push their heads right through and the percentage capture will thus increase again with decreasing size, another point of discontinuity, however, arising from the fact that some fish are retained at the gill covers, fish that would slip out backwards if the head were continuous in structure, and substance with the body.

The effect of this discontinuity in selective action of a net may be to give in some cases a falsely bimodal appearance to a unimodal frequency group. It is not possible without practical experiment to determine the relative positions of the modes of the two or three selection curves, but it would appear that they must be fairly widely apart, since only the largest fish in a catch are caught "by the nose", the great majority being caught between the gill cover and the dorsal fin. It may prove that the selection by the maxillary barbs and the gill covers have an insignificant effect, but, though this may be unimportant for the practical fisherman it may be of significance in research, in cases where modes appear in a frequency group deduced from a catch and on the upper side of the main mode thereof. It should be emphasized that, though the significance of the bimodal or trimodal selection in drift caught fish is open to argument, the fact of its existence is not open to argument, being self evident. To deny its existence is to affirm that there are no fish which would drop out of the net were it not for the presence of the gills or the maxillary angles. It would seem likely that small fish of slight power, such as sprats, would be more affected by multimodal selectivity of mesh than larger fish, such as herring or mackerel.

Unfortunately at present no data are available which are of any help in determining whether bimodality in selectiveness of a drift net is significant or not. For this purpose it is necessary to use at least three nets simultaneously, one having a mesh in which a number of fish of size "a" say are caught by the body, another of such a mesh that many of the fish of size "a" are caught "by the nose" and other, smaller, fish, caught by the body, the third net having a mesh intermediate between the other two. The only data bearing on selection by drift nets we have

are those from an experiment made with a fleet of mixed drift nets worked from the "George Bligh" in July 1923. Three of these nets had meshes of 35/yd., 38/yd. and 48/yd. respectively after shrinkage due to one shot. The results of the examination of these data have no bearing on the question of bimodality of selection, since, in the cases of the 35/yd. and 38/yd. nets, all the netted fish were caught by the body, while in the case of the 48/yd. net all or nearly all the fish were caught by the nose. One or more nets having meshes intermediate between 38/yd. and 48/yd. would be necessary to show up any possible effect of bimodality in selection. The data do, however, give strong indication that the selective action of a drift net is much sharper than has been supposed, — i.e. that the selection curve either for catching by the body and by the nose is not flat topped but of some form having a definite maximum point, and falling off steeply at first on each side. There is certainly here some support for the view that these curves resemble the Curve of Error in shape. If this is so, their effect must be to force this form upon the deduced frequency distribution curve, shifting the mode of the frequency group when the mode of the selection curve does not agree with the mode of the frequency curve, and at the same time giving a "skew" effect. The data mentioned above are treated in some detail by Mr. Hodgson in a subsequent paper.

Preliminary Note on Experiments concerning the Selective Action of Drift Nets

by

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In the foregoing paper Mr. WOLLASTON has suggested that the selectivity of a drift net is much sharper than has hitherto been supposed, and I propose here to analyse the catches of the three drift-nets already mentioned, and attempt to show the degree of selection observed.

The three nets, A, B and C had 35, 38 and 48 meshes per yard respectively, and were used on the grounds 25′ N.E. × N. of the R. Tyne on the night 9th/10th July 1923.

The fish from each net were measured and scales were taken for age-determination. The percentage length frequencies of each catch have been plotted as curves and are shown in Fig. 1 (see also Table 1).

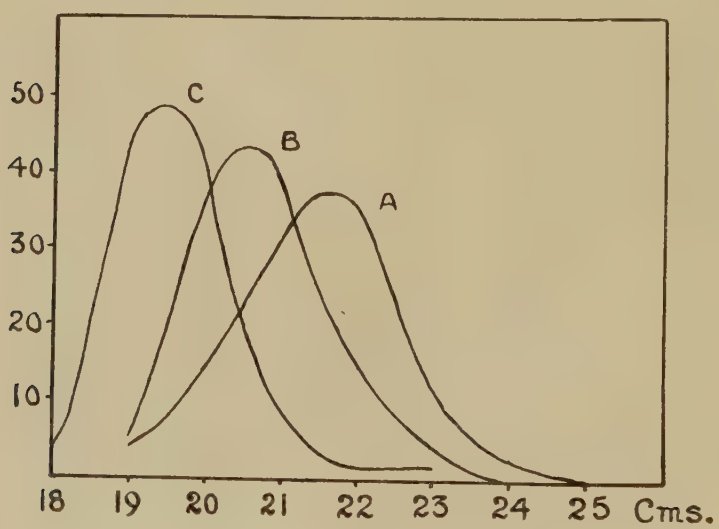


Fig. 1.

Table 1.

Net	Length in cms.								Total
A	18	19	20	21	22	23	24	25	
	—	6	21	46	52	17	4	1	147
	—	4.1	14.3	31.3	35.4	11.5	2.7	0.7	%
B	—	5	34	36	14	4	—	1	94
	—	5.3	36.2	38.3	14.9	4.2	—	1.1	%
C	3	36	34	7	1	1	—	—	82
	3.7	43.9	41.5	8.5	1.2	1.2	—	—	%

Here we have three different nets fishing at the same time and place and each giving distinctive size modes, the observed values being 21.6 cms., 20.6 cms. and 19.4 cms. respectively.

Had the net A (35/yd.) been used alone the percentage of fish at 19 cms. present on the ground would have been taken as 4.1 whereas Net C shows a percentage of 43.9 for this length.

The 48/yd. net is admittedly much finer than would be used commercially but the 35 and 38/yd. nets are frequently used by drifters especially on the grounds where this experiment was carried out.

The "sharpness" of the selection may be seen from the fact that in the three nets, in turn, 66.7 per cent., 74.5 per cent. and 85.4 per cent. of the fish are found in the commonest two centimetre groups. The steepness of the slope of curve C from 19 to 18 cms. is probably due to the absence of fish below 18 cms. but this cannot be the case with the other nets, as "C" proves clearly the presence of smaller fish than are caught by them.

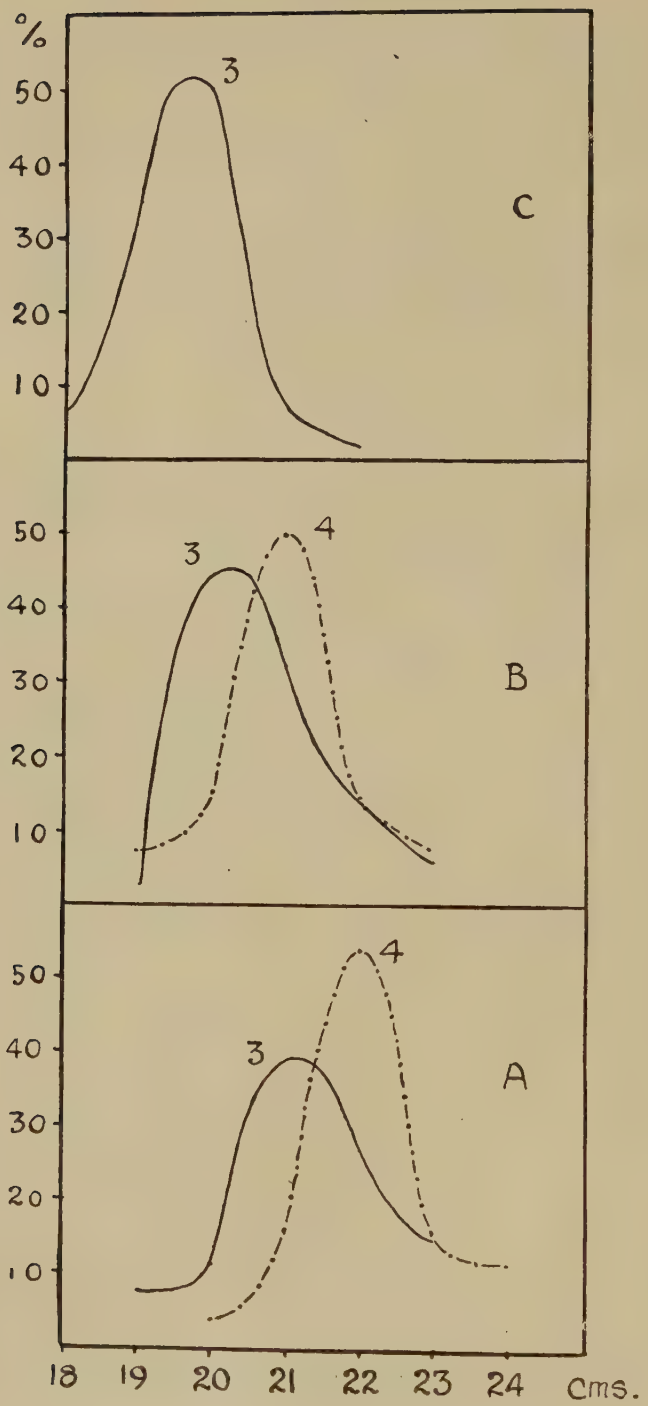
The age distribution of the herrings from the three nets is also interesting.

The ages and lengths of the age groups are as follows:—

Net A.

	Age			
	3	4	5	years
	26	26	2 = 54	

	Length											
	19	20	21	22	23	cms.		20	21	22	23	24	cms.
3-years	2	3	10	7	4 =	26	4-years	1	4	14	4	3	= 26
	7.7	11.5	38.5	26.9	15.4	%		3.8	15.4	53.9	15.4	11.5	%


%
50
40
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18
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20
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22
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24
Cms.

Fig. 2.

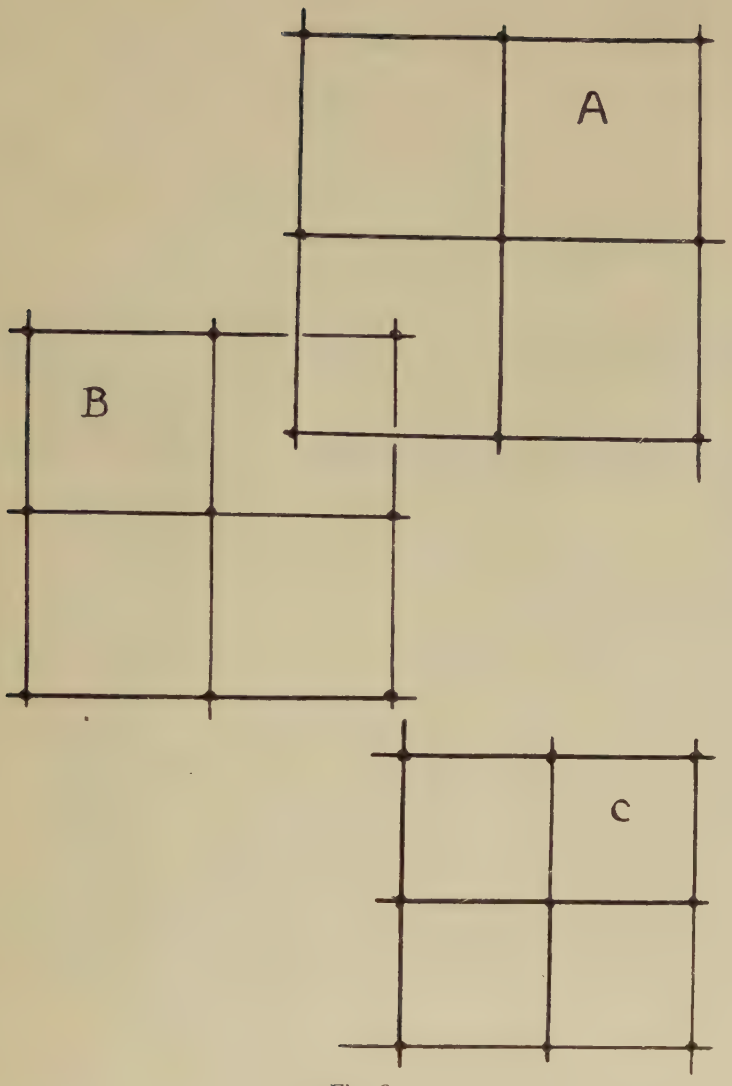

Fig. 3.

Net B.

Age

3	4	5	years
34	14	1	= 49

Length

3-years	19	20	21	22	23	cms.		
	1	15	11	5	2	= 34		
	2.9	44.1	32.3	14.8	5.9	%		
4-years	19	20	21	22	23	24	25	cms.
	1	2	7	2	1	—	1	= 14
	7.1	14.3	50.0	14.3	7.1	—	7.2	%

Net C.

	Age					
	3	4	years			
	46	2	= 48			
	Length					
	18	19	20	21	22	cms.
3-years	3	16	23	3	1	= 46
		6.5	34.8	50.0	6.5	2.2 %

Regarding the actual age-composition of the shoal on which are experimented, the above "age" tables show how unreliable the results can be. It is clearly seen here that the numbers of older fish vary directly with the size of the mesh, so it seems doubtful if it is possible to use a drift net to find the actual composition of the "stock" of fish on any ground.

The calculation of the length of an age group is equally difficult. In Fig. 2, the lengths of the 3 and 4 yr. groups are shown for each net. The young fish are grouped in three separate sizes all of which are probably below the correct value.

Fig. 3, shows the actual sizes of the meshes used in these three drift nets.

This elementary experiment indicates that a more extended investigation is needed, and the writer proposes to try the effect of larger meshed drift nets than are used commercially, on the autumn shoals off East Anglia. Although the scales which were examined in 1926 show that there were 7 and 8 year old fish on these grounds, it is felt that the size of the commercial mesh is inadequate, with the probable result that the drifters are landing large quantities of young herrings (before they have spawned) and are leaving the majority of the older ones — the "large fulls" behind.

Reviews.

Lieut. Commander E. H. Smith, U. S. Coast Guard. A Practical Method for determining Ocean Currents. Coast Guard Bulletin Nr. 14. Washington 1926.

This Bulletin is founded on a course of lectures given by Professor Helland-Hansen which the author, who is the oceanographer of the Atlantic Ice Patrol, attended at Bergen in 1925. The title is somewhat misleading since it is the indirect measurement of density currents by calculation from the observed salinity and temperature which is the subject of the work; direct measurement by any form of current meter is not discussed at all.

The larger part of the paper is given up to the calculation of the difference of velocity at different depths in a current by the methods which Sandström and Helland-Hansen have developed since the beginning of the century on the foundations laid down by V. Bjerknes. The problem is as follows.

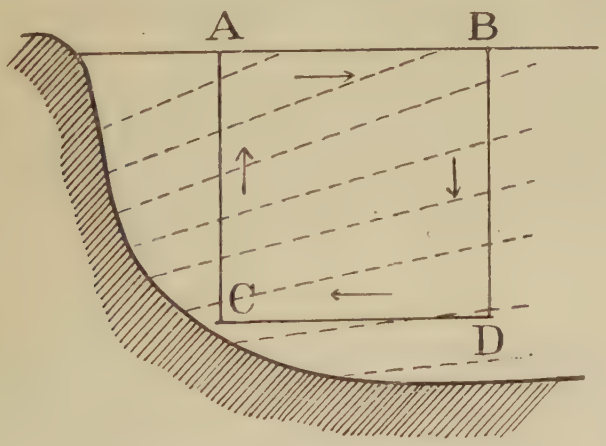

Fig. 1.

Let Fig. 1 be a vertical section drawn across a current, such for instance as the Labrador Current, so that the flow is southwards towards the reader. Observations of temperature and salinity have been made at a sufficient number of depths on the two verticals AC and BD and the corresponding densities, or better the specific volumes, the reciprocals of the densities, have been calculated and plotted as dotted lines. They show that the

water is divided into layers in such a way that the lightest water is found at the surface along the land and the densest further seawards in the depths, the layers themselves being tilted and wedge-shaped. In the absence of an on-shore wind we should expect the light water to rise and flow seawards and the dense water to sink and flow landwards so that the layers become horizontal and of uniform thickness. In other words we should expect a circulation to be set up in the direction of the small arrows. But observations show that the conditions remain nearly unchanged for weeks together and it follows that there must be some restraining force or forces acting in the opposite direction. One possible force is that of friction, but since this depends on the velocity and there is practically no velocity across the current, we may neglect it. The other is the deflecting force of the earth's rotation, directed to the right of the current in the northern hemisphere. In any one latitude it is directly proportional to the velocity of the current, and since the observations have shown that the upper layers are more tilted and crowded to the right than those in the depths, then the surface velocity must be greater than that of the deeper layers, which indeed is in agreement with common experience.

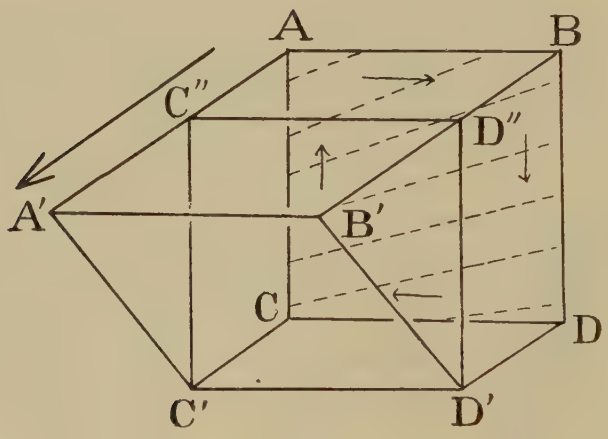

Fig. 2.

In Fig. 2 *ABDC* is a vertical cross section of the current as before and the rectangle *AA′B′B* is in the surface of the sea. Now imagine that the rectangle *ABDC* is drawn in the water with some coloured liquid. After one second the line *AB* will have moved to some such position as *A′B′* but the line *CD* only to *C′D′*. Then *C″A′* or *D″B′* is the difference between the velocities at the surface and at the depth *CD*. Consider next the projection of *ABDC* on the surface of the sea, which is obtained by drawing lines from every point of it to cut the surface at right angles. At first when *ABDC* is vertical its projection will be the line *AB*, which has no area. After one second, when it has taken up the position *A′B′D′C′*, its projection will have increased to *A′B′D″C″*. This area, the increase of the projection, is equal to the difference of velocity multiplied by the known

length AB. Hence if we can determine the area we can calculate the difference of velocity. And more, if CD is taken so deep that it has no appreciable velocity we can calculate the actual surface velocity.

V. Bjerknes has shown that we may do this by considering the "circulation" round $ABDC$. In mathematical usage the "circulation" round any closed curve, which may be a rectangle as here, is the total length of the curve multiplied by the average velocity of the particles along it.

In Fig. 3 the horizontal lines are drawn at equal intervals of depth, which is the same thing as equal intervals of pressure with sufficient accuracy for the present purpose, and the sloping lines at equal intervals of specific volume. Bjerknes has shown that if the intervals are properly chosen the number of parallelograms enclosed is equal to the force tending to set

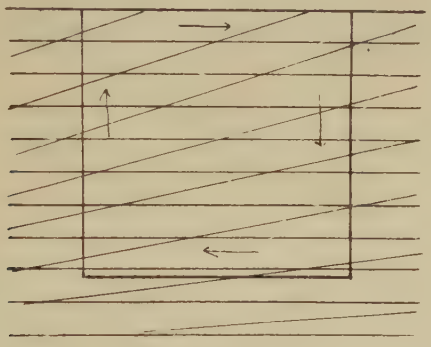

Fig. 3.

up the circulation shown by the arrows, and, since a force is measured by the acceleration which it can produce, the rate of increase of the circulation is equal to the number of parallelograms, in the absence of a counterbalancing force. This circulation is relative to the earth and due to the properties of the water so it may be called C_w, and if the number of parallelograms is A

$$\frac{dC_w}{dt} = A .$$

A curve fixed to the earth is carried round with it and when seen from a point in space has a circulation which we may denote by C_e; it is independent of the relative circulation. The equator has such a circulation. If the angular velocity of the earth's rotation is ω, $\frac{2\pi}{86164}$ since there are 86164 seconds in a sidereal day, and the radius of the earth is r, then it can be shown easily that the circulation of the equator is $\pi r^2 \times 2\omega$, that is, the area of the equatorial circle multiplied by 2ω. The formula is true of any other closed curve upon the surface of the globe if instead of "area of the equatorial circle" we put "area of its projection upon the equatorial plane". If this area is S, then

$$C_e = 2\,\omega S\,.$$

Observation shows that the conditions change only very slowly so that the force due to the difference of density must be almost exactly counterbalanced by others. One of these is C_e, and the other is friction. The velocity across the current is negligible so we may neglect friction in this direction. Hence

$$\frac{dC_w}{dt} = \frac{dC_e}{dt}$$

and

$$A = 2\,\omega\,\frac{dS}{dt}\,.$$

The value of $\frac{dS}{dt}$ is found as follows. It can be shown that if in latitude φ any curve such as $ABDC$ is projected upon the surface of the sea with an area σ and also upon the plane of the equator then the latter projection is equal to the former multiplied by the sine of the latitude. Hence

$$S = \sigma \sin \varphi$$

$$\frac{dS}{dt} = \frac{d\sigma}{dt}\,.\ \sin \varphi$$

and

$$A = 2\,\omega\,\frac{d\sigma}{dt}\,\sin\,\varphi$$

A can be calculated from the salinity and temperature, $2\omega \sin \varphi$ is known, and also one side of σ, that is of $ABDC$. The remaining side, the required difference of velocity, can therefore be calculated.

This is the original method of computation. In the first place the specific volume was calculated from each observation of temperature and salinity by means of the tables of Sandström and Helland-Hansen. The chief table, founded on Knudsen's Hydrographical Tables 1901 and Tait's figures for compressibility, gave the specific volume in situ in a sea of 0° C and a salinity of 35 pro mille; auxiliary tables provided corrections for other temperatures and salinities. Since it is the differences between stations which are of importance in the present case the figures may be made less unwieldy by working only with the corrections. The average value of specific volume in each layer was multiplied by the thickness of the layer and the whole summed from surface down to the depth in question, so as to obtain the integral $\int_o^p v\,dp$. The difference of these sums for adjoining stations is the required value A.

Lieut. Commander Smith describes the latest method of computation which makes use of the dynamic metre. Work is measured by the product of a force multiplied by the distance through which it acts. The force of gravity is g, about 9.8 on the metre-ton-second scale. It does g units of work when it acts through one metre and one unit when it acts through $\frac{1}{g}$ metres, 0.102 common metres; this is called the dynamic decimetre and the dynamic metre is ten times as great. Again if the vertical distance

between two points in the sea is D in dynamic decimetres and h in common metres, then $D = gh$. Also, the pressure at any depth h common metres in a sea of average density $\bar{q}$ is $hg\bar{q} = D\bar{q}$.

If d_A and d_B are the depths in dynamic decimetres at which some pressure p decibars is found on the verticals AC and BD, then the work done when a water particle is moved from one depth to the other is $d_A - d_B$, and we can write

$$d_A - d_B = 2\omega \sin \varphi \frac{d\sigma}{dt},$$

and the differences of velocity are calculated as before.

The specific volumes and dynamic depths are calculated by the tables of Hesselberg and Sverdrup, Bergens Museum Aarbok 1914—1915, no. 14. These are founded on those of Bjerknes and therefore on the more recent and accurate values of the compressibility determined by Ekman.

It is impossible for anyone to express an opinion as to the relative quickness of the two methods of computation unless he has had ample experience of both. The later method has, however, the advantage that the dynamic depths can be used for mapping the dynamical topography of the sea.

If a number of vertical series of observations are made over a large area it is generally found that at some considerable depth, a thousand metres or more, the temperature and salinity and therefore the specific volume are the same everywhere. We may assume that there is no motion here and that the corresponding isobaric surface which is obtained by calling metres decibars is a level one. We know the specific volumes on the verticals and so we can calculate the height in dynamic metres at which the other surfaces stand above it. The upper ones and in particular that of no pressure, the surface of the sea, will generally be found to slope and to resemble very gently undulating land. In May 1922 a difference of surface level of about 0.4 metres was found south of the Grand Banks in a distance of about 40 miles. The water tends to run down the slopes but is constantly deflected to the right by the earth's rotation. If we imagine that contour lines are drawn upon the surface we should find that the water follows them almost exactly; that it does not follow them exactly is due to friction. Such contour lines are practically the paths of the current.

It is regretted that it cannot be said that the author has been very successful in his attempt to give an account of dynamical methods. His paper is very hard reading and gives the impression of being the notes of a number of lectures which have been thrown together without much regard for order or the suitability of the material and then published without proper revision or proof reading. A failing which is particulary trying is the loose use of symbols. On page 16 for instance δ_o and δ_t are used instead of σ_o and σ_t, the abbreviated form of the density at 0° and t°, with which every oceanographer is familiar. Two pages further on δ_t is said to be density when 1000 (density — 1) is intended, and in the same line δ is used in its more usual significance of a difference or correction; at the same time δ_p is said to be a correction to density instead of to specific volume.

Since this Bulletin was written the methods have received a very practical application, which has been described in a later number. Lieut-Commander Smith while on duty with the Ice Patrol has carried out the determinations of salinity and calculated the dynamic height of the various surfaces above the level at which the pressure is 750 decibars, the greatest depth reached, and from these he has constructed the charts of dynamical topography of the surface of the sea. All this has been done at sea, for he remains on duty with the patrol for the whole of the season, so that he has been able to use the currents thus calculated for forecasting the probable drift of the bergs. It is as yet too early to say how successful the forecasts have been, but in any case the attempt is an advance on which their author is to be congratulated. D. J. M.

J. P. Jacobsen and Aage J. C. Jensen. Examination of Hydrographical Measurements from the Research Vessels "Explorer" and "Dana" during the summer of 1924. (Rapp. et Proc. Verb. Vol. XXXIX. 1926.)

In the main, this paper is devoted to an examination of hydrographical data, collected in the spring of 1924 during intensive co-operative cruises of the Scottish Research Vessel "Explorer" and the Danish Research Vessel "Dana" over the Faroe-Shetland Channel region and the approaches to the North Sea south of the Shetland Islands. Similar material, derived from a cruise of the "Dana" to Iceland waters later in the same year is also examined and in connection therewith observations furnished by Dr. Ed. le Danois are utilised.

The authors wish it to be understood that this hydrographical report, forming part of the "Report of the North-Western Area Committee for 1924 and 1925", is not an exhaustive treatment of the data of temperature, salinity and oxygen-content for this region which appear in the "Bulletin Hydrographique" for 1924, their object in publishing a report at the present stage being to furnish a guide for the planning of future surveys of this area.

The Faroe-Shetland Channel and North Sea Approaches between Scotland and Shetland.

In respect of the investigations under consideration, advantage is claimed over previous surveys of the same area, in that hydrographical stations were in this case more frequent and all observations taken within the short period of twelve days.

Approximately 100 stations, arranged in six different section lines, were worked by the above two vessels. Five parallel sections in the Faroe-Shetland Channel were chosen across the longitudinal direction of the Channel at intervals of approximately twenty-five miles south-westwards from "Section V" which lay along a line between Papa Stour, West Shetland, and the island of Svino, Faroes. A section running parallel to and just eastwards of a line joining Duncansby Head, Scotland and Sumburgh Head, Shetland, was surveyed firstly by the "Explorer" then, some

ten days later, by the "Dana", thus furnishing material for a comparative analysis which, however, has not been made by the authors. In addition to these, four sections lying *along* the longitudinal direction of and about the mid-Channel, were selected in consequence of and with the object of studying certain hydrographical peculiarities observed in this region.

The observations from the Faroe-Shetland Channel sections confirm conclusions arrived at by Helland-Hansen[1]) and later by Robertson[2]) in their examination of earlier material derived from periodic cruises of the Scottish Research Vessel, namely, that Atlantic water, characterised by temperatures in excess of 8° C. and salinities greater than 35.30 ‰ passes in a north-easterly direction through the south-eastern part of the Channel. This warm and salt layer contracts fairly rapidly as it approaches the Norwegian Sea, varying from a maximum (over the area considered) of 300—400 metres' depth and superficial 100 miles extent in the southernmost section to about 200 metres' depth and 70 miles extent over the most northerly section. This disposition of the Atlantic water is stated to be the effect of the current system in the Channel, a study of which, in conjunction with "oxygen-content" values, leads the authors to affirm that the warm and salt water of the upper layers was derived from the region west of the Faroes while the deeper water proceeded from the southward of Faroe Bank.

Norwegian Sea water with temperatures below zero and salinity about 34.92 ‰, which enters the Channel from the bottom of the Norwegian Sea at the north-western end of the Channel was met with in the deepest layers of all five sections, the layer being thickest in the north-eastern part of this particular area where it came within 400 metres of the surface at one station at least. Between these two layers of warm Atlantic water and cold Norwegian Sea water there was found to exist a layer of water approximately 500 metres thick, which the authors, in agreement once more with the above authorities, presume to consist of Arctic water (derived from the East Icelandic Polar Current) mixed, in the upper strata, with Atlantic water, and in the lower layers with Norwegian Sea water. The admixture of Arctic and Atlantic waters is stated to be due to eddy movements which are characteristic of the current system in the shallower portions of the area in question.

Of the afore-mentioned additional section lines lying in the longitudinal direction of the Channel, two were so chosen in order to bring out more clearly the differences in temperature and salinity prevailing in the north-western and south-eastern portions of the Channel. The disposition of isotherms and isohalines in these two longitudinal sections illustrates,

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[1]) B. Helland-Hansen: "Report on Hydrographical Investigations in the Faroe-Shetland Channel and the Northern Part of the North Sea in the year 1902". (Rept. on Fishery and Hydrographical Investigations in the North Sea and Adjacent Waters. Fishery Board for Scotland, 1905.)

[2]) A. J. Robertson: "Report on Hydrographical Investigations in the North Sea and Faroe-Shetland Channel during the year 1906." (Fourth Report [Northern Area] on Fishery and Hydrographical Investigations in the North Sea and Adjacent Waters. Fishery Board for Scotland, 1909.)

in the latter case, the greater abundance of Atlantic water in the section and, in the former, the predominance of Norwegian Sea water.

Temperature and salinity values for various depths from surface to bottom are tabulated in respect of selected stations at typical points in the Channel. These reveal the existence, during this period, of marked discontinuity layers in the north-western region.

Oxygen-content figures show that, at the surface, in the south-eastern area of the Channel, the water was almost saturated with oxygen, while the bottom layers were 17 per cent. short of saturation. There was no indication of marked sub-saturation at any particular depth, which, the authors state, "was indeed hardly to be expected in a water where the mixing is so great as in the Faroe-Shetland Channel."

Particular mention is made of the finding of a maximum oxygen-content value at depths of 400—500 metres at four[1]) stations on or about the western boundary of the Norwegian branch of the Atlantic Stream which, at this part, is just between 400 and 500 metres thick. The suggestion is put forward that this water had been in contact with the atmosphere more recently than adjacent layers above and below. Considerable super-saturation of surface layers down to 10 metres was met with at one station near the south-eastern end of the most southerly section, due perhaps to development of oxygen by vegetable plankton.

In addition to vertical section diagrams three charts are given showing the isotherms and isohalines in horizontal sections, at the surface, 300 and 500 metres. Similar observations regarding distribution of temperature and salinity are deduced from these as from the vertical graphs.

Differences in temperature (Δt) and salinity (Δs) between 100 m. and 50 m. are taken as indicative of the intensity of mixing of water layers and a figure, constructed on the basis of maximum and minimum differences in temperature, (Δs is not utilised by the authors) shows that mixing is most intensive within the 200 m. contours on either side the Channel. At the same time this chart indicates that down to 100 m. mixing takes place to a considerable extent beyond the 200 m. contours. A noticeable feature of the diagram is the comparatively great differences in temperature observed at all stations save one in "Section IV" (i.e. parallel to and about 25 miles S.W. of the most northerly section) to the east of Long. 5° W. indicating a strong flow of surface water in a south-easterly direction along that section, so strong in fact as to have a marked influence on the cold water under-layers, drawing these up on to the shelf in the south-eastern portion of the Channel.

By means of a temperature-salinity diagram the authors demonstrate the disposition of the waters of various origin which contributed to the Faroe-Shetland Channel complex, a matter of undoubted importance hitherto somewhat difficult to define, especially with regard to orientation. Pure or unadulterated Atlantic water was limited practically to the area or a portion thereof between the 300 metre contours and to a depth of 300 metres. The region to the N.W. of the 300 metre contour i. e. on the Faroe shelf, consisted mainly of Atlantic water more or less diluted with water of lower temperature and salinity.

[1]) Misprint in text here. "St. 11.9" should be "St. 11.19".

The bulk of the water in the Channel in layers below 300 metres, according to the results of Norwegian hydrographers, is Norwegian Sea water, although a small amount of water which, in respect of physical characteristics, is generally regarded as undiluted Atlantic water was observed beneath this depth as shown by the diagram. Conversely, water of low salinity and temperature was found in appreciable quantities above the 300 metre plane where, as stated above, the main bulk consisted of nearly pure Atlantic water. With regard to intermediate or mixed water layers the authors conclude from a study of the orientation of the symbols employed in their diagram that such layers were not formed by admixture of Atlantic and Norwegian waters solely, but must have contained water of still another origin, suggested by distinctly different physical characteristics, namely, a slightly lower salinity than that of Norwegian Sea water but a higher temperature. Of three possible sources of such water, the evidence of other investigators is strongly in favour of the East Icelandic Polar Current water. Coastal water from the northern coast of Scotland possesses a salinity much too low and temperature too high for it to be a likely source of the adulterant. Also water of salinity less than 35.00 ‰ is found west of the Wyville-Thomson Ridge only at depths below 1300 metres, so that this third possible source may be ruled out, since it is most unlikely that water from this depth could be carried across the Ridge which, at its deepest part, is but 550 m. beneath the surface.

The authors assume that water entering the North Sea between Orkney and Shetland at this time was only very slightly mixed if at all with coastal water from the Scottish shores.

The hydrodynamical treatment of observations in respect of the Faroe-Shetland Channel is a problem requiring considerable skill to present in a lucid form. Certain assumptions must be made to form a basis for inference and calculation and the ultimate value of conclusions or suggestions naturally depends very largely upon the inherent truth of such assumptions. Without a fairly intimate knowledge of the significance of the various physical and dynamical theories involved in this aspect of the subject it cannot be said that this part of the authors' paper will convey a very clear picture of the complicated relative movements of the various water masses in the Channel to any but mathematical hydrographers.

The topographical charts constructed for isobaric surfaces 100, 200 to 800 decibars at intervals of 100 decibars show that at the various depths the isobars followed much the same course although directions differed somewhat from surface to bottom. In mid-Channel the isobars ran in parts nearly normal to the longitudinal direction of the Channel, while the different isobaric surfaces came nearest to the geoid surface in the north-eastern and south-western parts, lying deepest in the south-eastern region.

In the following sentence the authors' meaning is obviously not the literal one and should probably read as given by inserting the bracketed words and deleting the one word in italics — "Reckoning from the surface current as *zero* (a basis for measurement) we can then, by means of the expression above noted, determine the (relative) currents at the different isobar surfaces, approximately situated at 100, 200 to 800 metres' depth."

But, as the authors proceed to state, more reliable results are obtained by taking as the basis for measurement the current at bottom which may be considered as zero with a fairer degree of approximation to fact. A chart showing the topography of the sea surface was constructed on the basis of the above assumption of zero current at bottom, and on the selection of a station in the most northerly section at which the height of the sea surface was taken as zero. From this chart the surface currents may be calculated and hence the currents at all intermediate surfaces. The construction of such a chart as above, for this area in particular, presents formidable difficulties in view of the complicated topography of the sea bottom and the consequent difficulty of determining the difference in height of the sea surface between pairs of stations situated fairly near to each other but of widely different depth. The mode of procedure employed by the authors is described in detail.

It appears from the same diagram that a decided minimum in the height of the sea surface existed in the neighbourhood of the station selected as a basis for calculation. About the middle of the southernmost section the sea surface attained a maximum height, within the area investigated, of 35 cms. above the zero station. Greater heights were recorded in respect of the region to the S.E. of a line joining the maximum and minimum points than over the area to the N.W. of this line, the general difference being about 10 cms.

Similar topographical charts for the 300 and 500 decibar surfaces possess in the main the characteristic features of the surface diagram.

From these charts currents are calculated by means of the formula $v = 43\frac{h}{l}$ where h is the increace in depth in dynamic centimetres of the isobar surface between two successive isobars and l is the distance in nautical miles between the isobars, v being the current difference in question.

A diagrammatic chart of the surface currents in the Channel shows that the main stream-drift flowed, with an average velocity of 40—50 cms./sec., in a south-easterly direction from an area to the west of the Faroe Islands. About Latitude 60° N and Longitude 6°20′ W this stream turned sharply eastwards and north-eastwards, thereafter travelling in a winding stream in mid-Channel more or less normal to the section lines. Over the entire area some half dozen eddy formations are exhibited, while three areas occur over which there appears to be no progressive movement of the surface waters, velocities being denoted as zero. One of these lies just to the east of the island of Sydero, Faroe, and two between Westray, Orkney and Sydero, Faroe, one on either side of the fast moving main stream-drift. At 300 and 500 metres' depth the currents in the south-eastern portion of the Channel were similar to those at the surface but in the north-western region, at 300 and 500 metres, the waters appeared to flow in a south-westerly direction contrary to what was observed at the surface at this part. At the entrance to the Channel also the water at 500 metres had quite a different course from that at surface and 300 metres.

An interesting observation arising from the surface current diagram is that the surface water entering the North Sea between the Orkneys and Shetlands appeared to come from the area to the west of the Faroes.

Further representation of the forces acting in the Channel is illustrated by vertical section diagrams for typical sections lying in the direction of and normal to the Channel.

The Waters around Iceland.

With regard to the hydrographical observations taken around the coast of Iceland by the "Dana" from June 1st to August 1st, 1924, along with which are considered the data collected by the French Vessel "Ville d'Ys" from 3rd to 17th May in the same year, the information derived agrees generally with the results of previous investigations, except that such low salinities as were found to the south of Reykjanes Peninsula (32 ‰) have not previously been recorded west of Iceland.

Twenty-four series of observations of temperature and salinity were made off Akranes, on the west coast of Iceland, between 9th June 1924 and 17th May 1925. The variation in these two physical factors is shown graphically for the surface, 25 and 50 metres. The maximum surface temperature occurred early in August 1924 approaching 11° C. but at 50 metres' depth a maximum temperature of over 9° C. was not attained until about a month later. The minimum temperatures for the whole water column occurred almost at the same time, the beginning of March. The curves of salinity for the above depths are less in conformity one with the other than are those for temperature. Salinity appeared to reach a minimum about November both at the surface and bottom, but in respect of maximum salinities their times of occurrence differed according to depth. While at bottom a maximum was observed at the beginning of July the salinity at the surface at this time was at a secondary minimum, between a principal maximum in April and a secondary in August.

The influence of wind on salinity distribution is exhibited in a chart which shows that a marked discontinuity layer rising towards the surface during calm weather, is driven down by stronger winds, which has the effect of producing a homohaline upper layer. Particular attention is directed to the phenomenon of salter water at 40—50 m. depth being lifted with increasing wind force. As the authors state, "the effect of direction of wind is not clearly apparent" from the figure. Generally speaking, however, a study of combined wind and salinity data shows that low salinity water was found at Akranes after southerly and easterly winds and high salinity water after northerly winds.

A short description of the method and apparatus employed in taking current measurements in Faxe Bay concludes this part of the Report.

J. B. Tait.

H. H. Gran und Birgithe Ruud. Untersuchungen über die im Meerwasser gelösten organischen Stoffe und ihr Verhältnis zur Planktonproduktion. Norske Vidensk. Akad. Oslo I. Matem. Naturvid. Klasse. 1926. No. 6.

Measurements were made, in various places and at various seasons, of the change in the oxygen content of sea water and of the organic matter

oxidisable by permanganate. Upon these are based calculations as to the photosynthetic production of organic substances, reckoned as glucose, per cubic metre — for the oxygen is the bye product of photosynthesis and the oxidisable matter has had its origin in photosynthesis save in contaminated inshore waters. GRAN (1923) showed that during the March diatom period as much as 1.4 g. glucose might be produced in three weeks under each square metre of surface down to a depth of 10 m. Culture experiments at the same time with a flask suspended at 1 m. depth showed that oxygen was produced corresponding to 0.3 g. glucose per cubic metre per day. The value agrees well with those obtained by GRAN, and GAARDER and GRAN in Oslo Fjord. PÜTTER obtained values at Kiel which were about ten times larger. ATKINS studied the yearly changes in alkalinity in the English Channel and found a minimum value of 3 g. dextrose per m^3. Comparing RABEN's values for combined carbon with LOHMANN's plankton data PÜTTER considered that by far the greater part of the carbon compounds were in the dissolved or suspended state, not in the plankton.

In Oslo Fjord the oxidisable organic matter was examined at various depths for a year, a minimum being found in mid-winter and a maximum in September. Its origin was partly from the plankton, partly from the land. The dissolved organic matter found to outweigh the plankton and detritus. Quantitative results are given and compared with those of other workers. W. R. G. A.

T. GAARDER and H. H. GRAN. Investigations of the Production of Plankton in the Oslo Fiord. Rapp. et Proc. Verb. XLII. pp. 1—48. March 1927.

The micro-plankton was investigated in March—April 1916 and August —September 1917 off Drøbak in Oslo Fiord, where abundance of organisms occurs in the upper layers of low salinity water. With winds blowing out of the Fiord this layer is reduced to a depth of about 5 meters, whereas inblowing winds pile up the layer to a depth of 30—35 meters. In spring the plankton consisted mostly of diatom species and in the late summer of dinoflagellates, infusoria and diatoms.

In order to assess, under as natural conditions as possible, the rate at which carbon compounds are produced by photosynthesis in excess of the loss in these compounds due to respiration, water collected in the Fiord was filled into one litre stoppered flasks which were suspended at various depths from a buoy for three days, one being shrouded with black cloth. In the case of water with its abundant plankton collected in March, those bottles suspended above 10 meters shewed an increase in oxygen, a rise in pH, and an increase in diatoms. Those at 10 meters shewed no change, while in those suspended in the darker regions below 10 meters the oxygen decreased, the pH fell, and the number of diatoms remained unchanged. The fall in oxygen in the flasks kept in darkness gave a measure of the total loss, due both to respiration by the contained organisms, including bacteria, and to the auto oxidation of organic matter in solution in the water.

The addition of phosphates and ammonium salts to the water at this

time of year did not materially affect the growth of algae during the first three days; the necessary nutrient salts appeared to occur in March in sufficient quantities, and did not limit the growth of diatoms.

On the other hand, water collected in September when suspended in stoppered flasks did not shew any marked production of oxygen and the plankton did not multiply profusely. The addition of phosphate, of nitrate, of ammonium chloride, or of phosphate and ammonium chloride caused increased production of oxygen. Most effective was the addition of phosphate and nitrate. It is concluded that in September the surface water of the Fiord contained insufficient quantities of nutrient salts to provide for a profuse vegetative growth.

These conclusions, based on direct experiment, are in line with the using up of soluble phosphates and nitrates which has been observed to take place between March and early September in the water of the English Channel.

An interesting point which is not discussed by the authors is their observation that the addition of ammonium salts alone increases the rate of photosynthesis. In the upper layers of the open sea available evidence points to these salts not being directly utilised in any quantity by the phytoplankton; numerous estimations of NH_3 in the sea do not indicate any seasonal variation in the quantity of this constituent present in the water such as occurs with phosphates and with nitrates. It appears probable therefore that the upper layers of Oslo Fiord, receiving city drainage and land washings, contain nitrate-forming bacteria such as have been found in other waters but not in the upper layers of the open sea well away from land, and that by their agency the added ammonium salts were changed into nitrates before being utilised by the plants. This is also in conformity with GAARDER and GRAN's observations that the addition of nitrate is more effective than the addition of ammonium salts.

Experiments were made to evaluate the quantity of organically bound carbon in the plankton and in solution in the water. A direct estimation of the carbon present in the plankton per litre of water in March was made by filtering through sand and combustion of the dried organisms. This gave values which were no more than roughly equal to the quantity of bound carbon which was produced by photosynthesis per litre in three days under normal conditions in the Fiord in March. Next, by counting the various organisms produced during three days in a flask suspended two meters below the surface, an estimate of the carbon in the protoplasm formed during this period was arrived at. This quantity was $^1/_3$rd to $^1/_5$th of the bound carbon produced by photosynthesis as deduced from the increase in oxygen which took place in the same flask. The authors therefore considered as extremely probable that the surplus of carbon products of photosynthesis is secreted from the plankton algae in a soluble or colloid disperse form into the surrounding sea water. It is to be expected that the permeability of the surface of these minute plants will alter as soon as they die, and any soluble matter will then rapidly diffuse out into the surrounding water, but it is difficult to comprehend why they should allow a large proportion of the organic matter formed within them to diffuse out during their active life, although they expose a very large surface to the water in comparison with their mass.

That plant organisms, after death or while living, secrete a relatively large part of their assimilates into their surroundings is borne out by estimates of the organic matter in solution. It was found that filtering off the great majority of plankton organisms through hardened paper from water samples collected in the Fiord did not reduce the oxidisable organic matter in solution to any considerable extent, a measure of this oxidisable matter being obtained by determining the quantity of permanganate reduced in hot solution.

From 5 to 6 times as much oxidisable organic matter was present in a soluble or colloid disperse condition as in the rich plankton and the quantity was very much greater in the upper layers where proliferation of the plants had taken place, than in the deeper layers. The $KMnO_4$ method gives a direct measure of the oxidisable but not of the total organic matter with which it is not necessarily in proportion.

These estimations shew clearly that the upper layers of this Fiord are singularly rich in dissolved organic matter: to what extent it is derived from drainage or from the assimilates of algae is not evident. It doubtless plays a definite role in the fertility of estuarine and inshore waters by nourishing bacteria, themselves the food of higher organisms, and possibly by nourishing directly many species of dinoflagellates which do not possess chromatophores. H. W. H.

H. H. Gran. The production of Plankton in the coastal waters off Bergen. March—April. 1922. Rep. on Norwegian Fish. & Marine Investigations Vol. 3, No. 8. Bergen 1927.

A north-going half knot current bathes the Norwegian Coast off Bergen, extending to seaward for 40 to 50 miles where it is bounded by warmer Atlantic water of over 35.2 ‰ salinity. This coastal stream is derived in part from cold low salinity water (0° C. and 25 to 32 ‰ S.) issuing from the Skagerak about one month previous to its arrival off Bergen, and in larger part from North Sea and Atlantic water which has mixed with it on the journey.

A luxuriant growth of diatom plankton, strikingly uniform in distribution, took place in this coastal stream in March, sharply defined to the westward on passing into Atlantic water and different in nature from the plankton flora of the inner waters of Hardanger Fiord, which extends far inland.

Continuous observations to a depth of 100 meters were made near an outer island within the track of this stream, the temperature remaining between 4 and 5° C. and the salinity between 33 and 34 ‰. At the beginning of March plankton was sparse; on the 13th an increase in the number of diatoms was noticed and rapid growth proceeded, the phytoplankton reaching a maximum about the 23rd. The predominant species were *Thalassiosira Nordenskioldii* and *Skeletonema costatum*, both of which attained a density of over 2000 individual cells per litre. By the 28th the maximum was passed and the greatest numbers were then and later found below the upper 10—20 meters layer, some species as *Skeletonema* showing a marked diminution earlier than others. With the decrease in phytoplankton there was an increase in infusoria.

The rich diatom community was found to extend uniformly to the edge of the Atlantic water on March 21st –22nd and on April 8th. On the latter date a number of diatoms had sunk into the salter layers below the coastal current; a different community of diatoms was found in the Atlantic water.

Contemporaneous with the rapid increase of diatoms in the water near the island, the dissolved oxygen increased at first in the surface layers and later at 20 to 30 meters depth, where the greatest number of diatoms were then present. After the 28th the dissolved oxygen gradually decreased, respiration by the plankton having more effect than photosynthesis, which had waned, the zooplankton having increased.

The increase in dissolved oxygen from March 13th up to the time when the maximum numbers of diatoms were found (March 23rd at the surface, 28th at 5 to 20 meters) was between 0.8 and 0.9 cc. per litre. It is most probable that this was due to oxygen given off during photosynthesis by diatoms. Taking into account a production of 1 cc. of oxygen per litre in the upper 10 meters layer only, this would correspond to the formation of 1.4 grams of glucose in each cubic meter down to a depth of 10 meters in the coastal current as it moved northward during this fortnight of rapid diatom proliferation.

Direct experiment indicated an even greater production. Flasks filled from the sea were moored one meter below the surface for 3 day periods and the increase in oxygen content determined. In order to ascertain and allow for the loss of oxygen due to respiration by the contained organisms, control flasks covered with black cloth were moored alongside.

From March 13th to 16th 0.71 cc. O_2 per litre were produced.
— — 16th to 19th 1.48 cc. O_2 per litre were produced.
— — 19th to 25th (no experiment)
— — 25th to 28th 0.65 cc. O_2 per litre were produced.

The author estimates that circa 3.7 cc. of oxygen per litre, corresponding to 5.2 grams of glucose per cubic meter of water, were produced during the fortnight of active diatom proliferation.

Rapid and considerable manufacture of carbon compounds by phytoplankton has previously been observed. Flasks filled with Kiel Sound water, rich in phytoplankton and nutrient salts, have been shown by Pütter to give off oxygen comparable with the production of 2.27 grams of glucose per cubic meter in 24 hours. During the vernal outburst of diatoms in Loch Strivan from April 2nd to April 7th, 1926, Marshall and Orr's observations of the increase in dissolved oxygen and decrease in dissolved phosphate indicated the production of about 2 grams of glucose per cubic meter in the upper ten meter layer. Estimations of the annual production in the English Channel by Atkins, based on the sum of the decreases in phosphate and in carbon dioxide, take no account of the phosphate being continuously regenerated and of carbon dioxide being continuously set free in the process of respiration Consequently the estimate is of the strictly minimum production, a point which is not mentioned by Gran in discussing this value. Actually Atkins' values of dissolved phosphate in the water at the International Station E_1 show that between

March 14th and April 22nd 1925 a fall occurred in the upper 20 meter layer amounting to about 25 mg. P_2O_5 per cubic meter, corresponding with a minimal production of some $2^1/_2$ grams of glucose per cubic meter during that period.

The cause of the sudden outburst of diatom growth off Bergen is not discussed. It would be interesting to know whether a marked increase in daily sunshine occurred about the 10th or 13th of March, since rapid utilisation of dissolved phosphate and carbon dioxide takes place in the English Channel at times roughly corresponding to the onset of over 3 hours sunshine daily.

The cause of the equally sudden dying out is attributed to the using up of phosphates and nitrates in the water, such as occurs after the vernal outburst of diatoms in the English Channel. Confirmation of this explanation was obtained by experiment; flasks filled with sea water at the time of maximum diatom growth and after, to which phosphate and nitrate had been added, increased in oxygen content to a greater extent than flasks of the water not so enriched, whereas the addition of nutrient salts had little effect in flasks filled from the sea before the outburst of diatoms had taken place.

Professor GRAN has contributed a valuable addition to our knowledge of the production of plankton in this publication, which includes a wealth of data concerning the density of diatoms, dinoflagellates and infusoria in conjunction with the hydrographical and oxygen changes. The experimental method of suspending flasks filled with the water under examination in the sea will doubtless be used in other areas. If the decrease in phosphate dissolved in the water in the flasks were estimated, this information would enhance the value of experiments with little extra expense of labour. H. W. H.

BIGELOW, HENRY B. Plankton of the Offshore Waters of the Gulf of Maine. Bulletin of the Bureau of Fisheries. Vol. XL, 1924, Part II. Document No. 968. pp. 509. 134 figs. Washington, 1926.

When Dr. BIGELOW made his first oceanographical cruise in the Gulf of Maine in July 1912, it was his good fortune to have what was practically virgin ground to survey, that is, as far as the plankton was concerned. With the exception of the years 1917—19 a yearly survey was made until 1920, and he has given us, in this report, a general account of the plankton he found. In all, up to 1920, he collected more than 1,000 samples, which, although taken with various types of nets and (with the exception of July and August) at irregular periods, suffice amply to give a general picture of the plankton communities of the Gulf and their movements.

The Gulf of Maine is an oceanic bight extending from Nantucket on the west to Cape Sable (Nova Scotia) on the east (between Latitudes 40° and 50° N); the 200 metre contour is taken as its offshore boundary, and beyond that is the inner edge of the Gulf Stream. The eastern part is almost cut off by two banks (George's and Brown's) which are pierced by two main deep channels. It will be seen that the paths for immigrants

are localised: 1) Those coming in the upper layers have free access to the gulf and 2) Those in deeper waters can only enter by the two channels.

The greater part of the report deals with zooplankton and contains a wealth of interesting data on its origin, distribution and fluctuations. During the summer months very large catches were taken: Dr. Bigelow frequently referring to the quantity in quarts and litres (e.g. 6 quarts of plankton in a 15 minute haul with a net one-metre in diameter at 40—0 metres). The zooplankton is dominated by the "Calanus (or general boreal) Community" which is characteristic of the upper 100 metres and includes besides *Calanus finmarchicus*, *Metridia lucens*, *Pseudocalanus elongatus*, *Euthemisto*, *Thysanoessa* and *Sagitta elegans*. *Calanus finmarchicus* is universal in the gulf, and is unquestionably the most important plankton species found; the average number below one square metre for May and June, for instance, was 96,000.

A second, less important association of species, is classified as the "Euchaeta Community", which was found in water deeper than 100 metres. The large copepod *Euchaeta norvegica* which was found in 80 per cent. of the hauls below 100 metres, is the principal form, and has in association with it the Chaetognaths, *Eukrohnia hamata* and *Sagitta lyra*.

Spring is the chief season of reproduction. Copepod nauplii are abundant in March and April in the coastal region, and this vernal wave spreads seawards, the copepods in the bay not reproducing until mid-May. These are included by Dr. Bigelow in a third community along with the young of other plankton animals, as the "Juvenile Community" which lives in the surface waters ("The nursery of the gulf" he calls the upper 50 metres). Copepods reach their maximum in June; as their numbers dwindle other boreal forms increase (e.g. *Euthemisto* and Euphausiids). The seasonal cycle is simplified as compared with European waters, because most members of the zooplankton are endemic, and few immigrants enter the gulf. The fluctuations are greatest where neritic larvae bulk large in the pelagic community; there is also a decided decrease at the time of the vernal flowering of diatoms. It is of interest to note that Dr. Bigelow believes that the Gulf of Maine is a breeding ground for that important euphausiid, *Meganyctiphanes norvegica*, and that this species is regularly endemic there; he further considers the gulf to be the most southerly important centre of distribution off the American coast.

The eddy-like circulation of the gulf parallels the coast, confining neritic species to a narrow belt of water. The scarcity of pelagic animals of neritic origin in the offshore areas (100 metres), leaves the central basin occupied by oceanic forms which are confined to this area by the high temperatures of the tropical waters to the east of the basin; they are not the product of the Atlantic basin outside the continental slope, but of the banks water that washes the continental shelf on both sides of the Atlantic.

Immigrants, as noted above, are not common; they can enter the gulf by three sources: 1) The Gulf Stream; 2) The Nova-Scotian (arctic) current; and 3) In the "Cold Wall" current. The latter is a mixture of coastal water with 1 and 2. All visitors follow the line of the anti-clockwise current within the gulf; those in the upper strata rarely reach the central part unless their numbers are fortified by local reproduction. Tropical visitors

are rare, in spite of the proximity to the Gulf Stream, and usually only single specimens are captured. Among the arctic immigrants are *Oikopleura vanhöffeni*, *Calanus hyperboreus*, *Metridia longa* and *Clione limacina*. *Calanus* and *Metridia* probably breed locally. The indraft of water through the eastern channel (i.e. the deeper layers) is fairly constant in its physical characters and carries with it species such as *Euchaeta* and *Euthemisto*, which are successful colonists. Tropical and arctic visitors usually arrive via the superficial water stratum, but the immigrants in the mixed water arrive at all depths, and this source of replenishment is always available.

Little work has yet been done on the food of fishes, and the section dealing with this problem is mainly a review of other people's work, but there are some data in connection with the feeding of whales: The Fin-back-whale feeds on euphausiids and herring; the Blue-back on euphausiids alone, whilst the Pollack whale subsists chiefly on copepods with some euphausiids. By means of photographs Dr. Bigelow shows that the ability to capture small creatures like copepods depends upon the relative fineness of the bristles on the inner side of the baleen plates.

The data for a comprehensive survey of the phytoplankton is not nearly so large as for the zooplankton, principally owing to the lack of spring samples in most of the years covered by the report. There is sufficient evidence however to show that there is the usual tremendous spring flowering of diatoms; this is succeeded in summer by a peridinian flora — chiefly *Ceratia*, and there is a suggestion of a secondary maximum of diatoms in autumn.

The causes of the vernal flowering of diatoms are considered in a section dealing with the biology of the phytoplankton. Nitrates, silicates and phosphates are all brought under review as possible limiting factors. The supply of nitrogen and silica is shown to be greatest at the time, and phosphoric acid is assumed to be so too, but as Dr. Bigelow says: "Our Gulf of Maine studies touch only the outer edge of this very complex subject".

There are many points of interest in the report which cannot be touched upon here. Most of the species of animals and plants are described separately and distributional charts given for the most interesting. There is also a series of 36 most excellent photographs illustrating all the different types of plankton, and finally there is a comprehensive bibliography. Our thanks are due to the author for producing this work which will be appreciated by all planktologists. R. E. S.

F. S. Russell. The Vertical Distribution of Marine Macroplankton. V. The Distribution of Animals caught in the Ring-trawl in the Daytime in the Plymouth Area. Journal of the Marine Biological Associaton of the U. K., N. S., XIV, pp. 557—608 (1927).

In this latest instalment of his series of papers dealing with the vertical distribution of plankton Mr. Russell publishes the details of the captures of invertebrates made in 1925 in daylight hauls of known depth (not in 1926, as is inadvertently stated in his summary). The fishes taken in these

hauls have already been described in part III of the series, reviewed in Vol. II, No. 1 of this Journal.

The paper is, as he states, rather a collection of data than of deductions, the accumulation of observations making it increasingly difficult to formulate definite conclusions as to the causes of the movements of the plankton. The light factor still seems to be the governing motive, but interesting departures from the general scheme are noted. Thus the adult males and the younger copepodite stages of Calanus both vary, but in different directions, from the rules of conduct of the females, the males being less and the young stages more attracted by light than the females. Tomopteris, which in the earlier months of the year was only taken in midwater night hauls, appeared in numbers in July and August in townettings taken by day in the upper layers. In general, however, the records support the conclusion already arrived at by the author that light is the principal factor in the vertical distribution, the relative positions of most of the species remaining the same though their actual depths varied from day to day, evidently in accordance with the intensity of the light. The author makes a strong case for the reliability of non closing nets, when used horizontally at serial depths with sufficiently small intervals between them and hauled for a sufficiently long time, indicating by calculation from an actual example how small is the error introduced by the fishing of the nets whilst being hauled. Hjort has already pointed (Depths of the Ocean, pp. 102, 616) how such nets can be used with profit in very deep water, provided that due allowance is made for the catch taken whilst hauling.

In the paper the numbers of the various species and, where necessary, of the different developmental stages, taken in about 100 hauls on seventeen different occasions, are given in tabular form and commented on, but the correlation of the distribution with the factors which may have influenced it has been deferred until a further series of townettings made in 1926 has been worked out. It is hardly necessary to comment on the value of the information thus supplied in a readily handled form, and the only criticism that presents itself is that more details of the light intensity, which is noted merely as "sunshine" or "dull", would be acceptable.

G. P. F.

A. Candeias. Première Liste des Copépodes des Côtes du Portugal. Bull. de la Société Portuguaise des Sciences Naturelles. Tome X. No. 3. Dec. 1926.

Senhor Candeias here publishes a preliminary list of oceanic copepoda from the coast of Portugal, based on thirteen townettings, all surface gatherings except one, taken between Cape St. Vincent and the Straits of Gibraltar. One station, No. 17, is however evidently wrongly located as the recorded position (37°35′ N., 8°32′30″ W.) places it some miles inland. *Camera lucida* drawings of several of the less well known or unexpected species are given in confirmation of the accuracy of their identification.

Prof. Otto Pettersson has recently put forward a plea for the establish-

ment of lists of plankton characteristic of the principal oceanic currents, and this paper should be welcome as a contribution to this end, dealing as it does with a region whose hydrographic relations are well known. The salinities and temperatures on most of the stations can be ascertained, though this fact is not mentioned in the paper, from the Bulletin Atlantique for 1925, the townettings having been taken during the course of the Portuguese hydrographic cruises made in that year in pursuance of the International Council's programme. The salinity in every case is high, on most of the stations being above 36.00 ‰.

Several interesting species are recorded in the paper. Thus *Centropages Chierchiae* seems to replace entirely the closely allied *Centropages typicus* characteristic of more northern waters. *Euchaeta media*, a common Pacific species but only known previously in the Atlantic from the east coast of North America, occurred in small numbers on one station and *Euchaeta hebes*, an occasional visitor to the mouth of the English Channel, was taken in abundance on one station. G. P. F.

Roderick Macdonald 1) Food and Habits of *Meganyctiphanes norvegica*, 2) Irregular development in the Larval History of *Meganyctiphanes norvegica*. Journ. Marine Biol. Assoc. XIV, No. 3, p. 753.

1) In this timely paper Mr. Macdonald gives an account of the food and habits of *Meganyctiphanes norvegica* in the Clyde sea-area. There is a good description of the animal, and especially of its pigmentation and luminescent organs. He comes to no definite conclusions as to the function of these organs, though suggesting that they may "assist and elaborate the visual sense". He finds that Meganyctiphanes, kept in darkened tanks, may live for 9 weeks, the shortest lived surviving 3 weeks, whereas in undarkened tanks none were found alive after 15 days. Since the latter died, in many cases, at moulting, it suggests that light has a harmful effect which takes toll especially at the moulting crises.

Mr. Macdonald finds that, during the day, Meganyctiphanes is most commonly found in the deeper waters (60—80 fthms.), within ten fathoms of the bottom. He gives two tables showing the catches of Meganyctiphanes at different levels throughout two 24 hour periods. Both tables show that the vertical distribution of Meganyctiphanes becomes restricted during the day to the deepest levels (65 fthms): at night specimens may be met with at all levels, this change being rather due to a spreading and scattering, than to a definite mass-migration towards the surface. A similar phenomenon is demonstrated less convincingly for *Thysanoessa Raschii*, *Euchaeta norvegica*, and *Calanus finmarchicus*. Mr. Macdonald suggests that the stimulus to migrate is probably "a summation of many factors".

Mr. Macdonald records some interesting observations on the manner in which Meganyctiphanes feeds in captivity, and gives, in two tables, the results of investigations into the food of this animal, in the Clyde sea-area, over a two-year period. He shows that Meganyctiphanes is a suspension feeder, and that vegetable detritus of coastal origin is of great importance as food for adult Meganyctiphanes of all sizes, especially during the first three months of the year. He found no difference between the

food of specimens caught by day and by night. Smaller specimens tended to take more diatom and dinoflagellate food, the spring outburst of diatoms being clearly reflected in the food of small and medium Meganyctiphanes, whereas larger specimens are predatory in habit.

The whole paper suggests that "the bottom deposits . . . are important factors in the distribution of Meganyctiphanes". In view of the immense importance of kril to the deep-water fisheries in particular, we sincerely hope that Mr. MACDONALD will extend his research to cover the food of kril in more typical areas, and throughout the seasons there. It may be that the great migrations of kril are due, in part, to a seasonal change in feeding habits.

The tables in this paper, unfortunately are not self-explanatory, and require frequent reference to the text; there is a slip on p. 756 line 6 — "Lat. 24° N." should surely be "Lat. 74° N.".

2) In this paper Mr. MACDONALD describes and figures a new type of Nauplius belonging to *Meganyctiphanes norvegica*, which is hatched from a larger type of egg than the more familiar larval form. He gives evidence of the "jumping" of larval stages in the development of Meganyctiphanes, and suggests that this foreshortening of the life history is "an indication of evolutionary progress" in the Euphausiacia.

C. F. H.

1) MARTIN KNUDSEN. A Bottom Sampler for Hard Bottom.
2) A. C. JOHANSEN. Preliminary Experiments with Knudsen's Bottom Sampler for Hard Bottom.
Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, Bind VIII. København. 1927.

Those who have used the "Petersen Grab" bottom sampler have realised its serious lack of penetrative power on compact sandy and gravelly bottoms. A new instrument for sampling such bottoms has now been designed by Professor MARTIN KNUDSEN and an account of its preliminary trials has been furnished by Dr. A. C. JOHANSEN.

An iron cylinder, open below, is fitted above to a chamber containing a water pump. The pump is surmounted and driven by a revolving drum, on which is wound the same cable that is used for lowering and raising the instrument. During descent the drum is kept from revolving by a catch, which, on arrival at the bottom, is automatically released. The cable is then hauled, thereby rotating the drum and pumping water out of the cylinder, which is thus driven into the bottom by the downward acting pressure developed. When the drum is fully unwound an ingenious device frees the cable to operate a lever by means of which the whole instrument is tipped through 180 degrees and hauled on board with the cylinder mouth directed upwards. The cylinder has a cross section area of 0.1 sq. metre and the sampler is therefore comparable with the 0.1 sq. metre "Petersen Grab".

The principle of this ingenious apparatus embodies a new and useful idea in the "tipping" mechanism for retaining the sample. The pumping device is also new, though the idea of developing a pressure potential to

fill the sampler has already been employed in the small bottom sampler ("Vacuum Grab") designed at Plymouth and described by the present writer.

The trials by Dr. JOHANSEN shew that the Knudsen sampler, working on hard, sandy bottoms, obtains a much greater amount of bottom material than the "Petersen Grab", with a correspondingly greater number of organisms per unit area of bottom. The cylinder penetrates some 30 cms. as compared with 0.5—3.0 cms. for the grab, and thus the deeper-living animals are obtained. Figures given for the catches of both instruments on hard sand shew very strikingly the superiority of the Knudsen sampler.

It will be seen that the new sampler is necessarily somewhat complicated and it seems probable that this will militate against its adaptability, as it stands, for general use. The greatest depth of water from which results are reported by Dr. JOHANSEN is 14 metres in the Køge Bugt. The weather conditions are not stated. The use of the drum-pump mechanism would present practical difficulties in deeper water, and the absence of calm conditions would accentuate these, as well as the difficulty of controlling the effects of "stray" of the cable. On the whole it would appear that the apparatus is very successful under conditions such as those in which it has been tested, that is, in shallow waters in, presumably, calm weather, and, given such conditions, it will undoubtedly perform invaluable service. For more general use, however, in such waters as the open North Sea, it may be predicted that the instrument as described, with its cable-driven pump and long lever-arm, would not be very suitable, though the embodied principles — utilisation of pressure and the "tipping" idea — will be of great value to all concerned in the further elaboration of methods for the quantitative investigation of marine bottom populations.

O. D. HUNT.

ROBERT S. CLARK, M. A., D. Sc. Rays and Skates, a revision of the European species. 44 Text figs. and 36 plates. Fishery Board f. Scotland, Scientific Investigations 1926, Nr. I. Edinburgh (1926).

Der Verfasser dieser ausserordentlich verdienstvollen systematischen Bearbeitung der europäischen Rochenarten hat seinen Beruf für diese ebenso verlockende wie schwierige Aufgabe durch eine im Oktober 1922 im Plymouth "Journal of the Marine Biological Association" (vol. XII, 4, p. 577—643) veröffentlichte Abhandlung über die Eikapseln und Jugendformen von 9 Rochenarten erwiesen. Diese Eier waren von sicher erkannten Mutterfischen gewonnen, wurden im Aquarium zum Ausschlüpfen gebracht, und so weit als möglich wurde die Dauer der Inkubation und die Beschaffenheit und Metamorphosen der frühesten Jugendformen bestimmt.

Schon bei dieser Arbeit hatte sich für den Verfasser die Notwendigkeit ergeben, sich mit der Synonymik und der äusserst verworrenen Nomenklatur in dieser Fischfamilie auseinander zu setzen, und Vergleichsmaterial des Fishery Board for Scotland, das Dr. BOWMAN zur Verfügung stellte, hatte dabei wertvolle Dienste geleistet.

Nach diesen vorbereitenden Studien lag es für den Verfasser nahe,

als er von Plymouth nach Aberdeen zum Laboratorium des schottischen Fishery Board übersiedelte, das ausserordentlich reiche Anschauungsmaterial, das der grosse Fischmarkt zu Aberdeen ihm bot, für die Fortsetzung und Vertiefung seiner systematischen Studien zu verwerten, und dabei die Sisyphus-Arbeit zu übernehmen, in die Charakterisierung und Benennung der europäischen Rochenarten Ordnung zu bringen, nachdem die grosse Zahl der früheren Bearbeiter aus Mangel an Anschauung und kritischer Vertiefung an der Lösung der Aufgabe gescheitert waren und vielfach die herrschende Verwirrung noch vergrössert hatten.

Nur eine weitgehende Berücksichtigung der Jugendformen und ihrer Veränderungen beim Wachstum und ein so grosses und vielseitiges Untersuchungsmaterial, wie es der Markt von Aberdeen, Plymouth und Lowestoft, das Museum in Kopenhagen und einige Mittelmeerplätze wie Malta und Neapel zu bieten vermochten, ermöglichten es dem Verfasser zum Ziele zu kommen und damit eine längst empfundene Lücke in unserer Kenntnis der europäischen Fischfauna und noch dazu einer Familie, der auch viele Nutzfische angehören, auszufüllen.

Angaben älterer Autoren konnten nur mit grösster Vorsicht benutzt werden; nur wenige derselben fussen auf einem grösseren Material und sind entsprechend zuverlässig, wie z. B. diejenigen von E. W. L. Holt und Calderwood.

Alle zur Untersuchung gelangten Exemplare — und es handelt sich um tausende — wurden sorgfältig gemessen und in ihren Konturen kopiert. Für 10 von den im ganzen beschriebenen 23 Arten, finden sich Abbildungen im Text, die die Veränderungen der Körperkonturen im Laufe des Wachstums erkennen lassen; für 17 Arten sind je eine oder mehrere photographische Aufnahmen der Kiefer mit ihrer nach Form und Reihenzahl charakteristischen Bezahnung wiedergegeben, von 4 Arten sind die Eikapseln abgebildet und 20 Arten sind in — teilweise mehrfachen — photographischen Habitusbildern festgehalten.

Die Benennung der einzelnen Formen ist unter strikter Beobachtung der Regeln der Nomenklatur und auf der Basis einer sehr weitreichenden und gut belegten Kenntnis der Literatur erfolgt. Nur in wenigen Fällen könnte die Berechtigung der Namengebung als strittig angesehen werden, z. B. bei *R. montagui* Fowler statt *R. maculata* Mont. und *R. brachyura* Lafont statt *R. blanda* Holt u. Calderwood. Hier lag kein zwingender Grund vor, von den irischen Autoren abzuweichen.

Auf die Zusammenstellung eines Bestimmungsschlüssels für alle in Betracht kommenden Arten hat der Verfasser absichtlich verzichtet; die grosse Variabilität der benutzbaren Charaktere macht ein derartiges Hilfsmittel unzulänglich und daher überflüssig. Ausser den schon erwähnten Merkmalen ist auch die horizontale und bathymetrische Verbreitung der einzelnen Formen als Hilfsmittel für ihre Identifizierung benutzt worden.

Das systematische Studium ging, wie schon erwähnt, von den in Plymouth zugänglichen Arten des südwestlichen Gebiets aus, elf an der Zahl, von denen sieben auch im Mittelmeer vorkommen; es wurden dann noch fünf weitere Mittelmeerarten studiert, von denen drei in ihrem Vorkommen auf das Mittelmeer beschränkt sind.

Von den elf bei Plymouth festgestellten Arten wurden acht auch in den schottischen Gewässern gefunden, nämlich:

R. clavata L.	*R. circularis* Couch.
R. montagui Fowler	*R. fullonica* L.
R. brachyura Lafont	*R. batis* L.
R. naevus M. u. H.	*R. oxyrhynchus* L.

dagegen nicht die drei Arten:
R. microcellata Mont., *R. undulata* Lacep. und *R. marginata* Lacep.

Für die nördlichen Gebiete, aus denen der Markt von Aberdeen versorgt wird, wie das Barentsmeer, Island, Färöer und auch die atlantischen Gewässer von Irland kommen noch sechs weitere Arten in Betracht nämlich:

R. radiata Don.	*R. fyllae var. lipacantha* Jensen
R. hyperborea Collett	*R. nidrosiensis* Collett
R. fyllae Lütken	*R. lintea* Fries

In buchtechnischer Beziehung ist zu bedauern, dass der Druck der Arbeit so wenig gegliedert ist, dass die Übersicht ungemein erschwert wird. Durch Nummerierung der einzelnen Arten, durch Überschriften in Gross- oder Fettdruck und durch reichliche Spatiierung zwischen den einzelnen Abschnitten der Arbeit hätte sich der äusserliche Gesamteindruck leicht verbessern und die Auffindung von Einzelheiten wesentlich erleichtern lassen. E. Ehrenbaum.

F. S. Wright. A Report on the Cockle Beds and the Cockle Industry of England and Wales. Ministry of Agriculture and Fisheries. Fishery Investigations. Series II. Vol. IX. No. 5. 1926. London 1927.

This work contains a brief yet concise account of the natural history of the Cockle (*Cardium edule*), of the cockle beds of England and Wales with the methods of fishing for this mollusc, the maintenance of the cockle beds, their productivity and the food value of the cockle. The detailed observations on the life history and bionomics of the cockle were made by Mr. Wright on the famous beds at Llanrhidian sands of the Gower coast of Glamorganshire.

Mr. Wright gives an interesting account off the life history of the cockle, its breeding habits and rate of growth. He shows that the increase in bulk and flesh weight is roughly proportional to the growth in length and that as a rule the concentric grooves on the shell are growth-rings indicating the age of the mollusc. One groove is usually formed each year. Mr. Wright also gives us some data regarding the communities of plants and animals associated with the cockle on the sands in Swansea Bay and the estuary of the Burry River. Methods of determining the productivity of a cockle bed are also given in some detail and a comparison is made between such productivity and that of cultivated land. His results differ considerably from those previously obtained by Johnstone for cockle beds on the Lancashire coast. Wright estimates the productivity of a cockle bed in South Wales to be approximately 330 kg.s per hectare, whereas Johnstone's estimate was only 66 kg.s per hectare.

The food value of the cockle is shown to be high, though it is not so valuable as either the oyster or mussel.

The quantity of cockles landed in England and Wales for the three years 1923, 1924 and 1925 was 167,089; 231,001; and 300,721 cwts. respectively. In addition there is, what will be a surprise to most people, an importation of foreign cockles into England from Holland amounting during 1923 to the value of £ 1,829.

The chief difficulty in extending the home trade for cockles is the fact that these shellfish are liable to be contaminated by sewage and so are dangerous for human consumption. Mr. WRIGHT shows how this danger may be avoided and the trade in cockles increased by a simple process of sterilisation.

Mr. WRIGHT is to be congratulated on the production of a paper which fully maintains the high standard set by the Ministry of Agriculture and Fisheries in their official publications dealing with fishery problems. It will prove of interest not only to scientists interested in shore communities of animals and plants but also to practical men interested in the cockle trade which at present is declining on some parts of our coast, e.g. in Lancashire. The adoption of the methods of cooking and preserving described by Mr. WRIGHT at Leigh-on-Sea, would, if adopted elsewhere, undoubtedly lead to an increased market for the cockle and provide not only an additional source of income to our inshore fishermen but an increased yield in an article of food which is much appreciated in our large industrial centres, particularly in the North of England.

The work is, as far as we can judge, free from error and is thoroughly to be recommended to all those interested in this branch of the fisheries.

J. T. J.

Current Notes.

Untersuchungen des Reichsforschungsdampfers „Poseidon" im Barentsmeere. Juli bis September 1927.

Die im Jahre 1913 auf einer Fahrt des Reichsforschungsdampfers "Poseidon" seitens der Deutschen wissenschaftlichen Kommission für Meeresforschung begonnenen deutschen hydrographischen und fischerei-biologischen Arbeiten im Barentsmeere wurden im vorigen Jahre mit dem Fischereischutzboote "Zieten" wieder aufgenommen[1]); in diesem Jahre konnten sie mit dem Reichsforschungsdampfer "Poseidon" auf einer zweimonatigen Fahrt (20. Juli—21. Sept. 1927) fortgesetzt werden. Die Arbeiten erfolgten nach einem mit Russland vereinbarten Plane und umfassten in erster Linie eine vollständige Untersuchung der hydrographischen Verhältnisse vor allem im Monat August. Deutschland hatte dabei die Arbeiten bis 38° O-Lg übernommen, und zwar die Gewinnung hydrographischer Schnitte auf 19°, 26°, 30°, 33½°, 38° O-Lg von der Küste bis zur Eisgrenze, die Beobachtungen östlich 38° O-Lg fielen Russland zu. Ausrüstung und Personal für die hydrographischen Arbeiten wurden von der Deutschen Seewarte gestellt (Prof. Dr. B. Schulz als Fahrtleiter, Kapt. Hatje, Dr. Zorell, Dr. Ritter, cand W. Schott), für die biologischen Arbeiten von der Staatlichen Biologischen Anstalt auf Helgoland (Dr. Bückmann). Auf der Spitzbergenbank wurden ausserdem fischereiliche Untersuchungen durch Fischereidirektor Lübbert in Hamburg ausgeführt. Die Fahrt war durch das Wetter begünstigt, sodass das Programm voll durchgeführt werden konnte.

G. Schott.

[1]) Vergl. B. Schulz und A. Wulff, Hydrographische und planktologische Ergebnisse der Fahrt des Fischereischutzbootes "Zieten" in das Barentsmeer im August—September 1926. Berichte der Deutschen wissenschaftlichen Kommission für Meeresforschung, Neue Folge, Band III, Heft 3. Berlin 1927.

Russian Investigations in the White Sea and Barents Sea (1927).

The Scientific Institution of Fisheries (Moscow) purchased in the current year (1927) a sail-and-motor cutter the "Polar Star" for investigations in the White and Barents Seas. Its length is 17.3 m.; the Motor is 60 H. P. Besides the captain, engineer and 5 sailors there is room in it for 4 scientists. In the period between June and July the "Polar Star" has made two trips in the White Sea, for investigating the hydrological conditions and for gathering material on bottom fauna and plankton. Simultaneously with this work there have been made experiments on fishing for herrings with drift nets, and there has been collected extensive material on young *Clupea harengus*, *Eleginus* (*Gadus*) *navaga* and *Pleuronectes flesus*.

At the end of August the "Polar Star" arrived at Alexandrovsk on the Murman coast, this coinciding with the arrival of the Steamer "Poseidon", belonging to the German Scientific Expedition. The scientists of the Institution made a trip on the "Polar Star" and then on the "Poseidon" with the members of the German expedition, headed by Prof. Bruno Schulz.

On the 27th of August the "Polar Star" put out to sea and began its work from the frontier with Finland up to the Sviatoy Nos (Holy Cape) at the entrance to the White Sea. These investigations lasted for two months and not until the 21st of October did the ship return to Archangel. During the time of its cruise in the coastal zone there was collected abundant material on the edible fish of the White Sea both young and mature, mainly on Cod, Plaice and Flounder. These collections are intended to be studied during the winter, and it is proposed to go on with the collection of the material required for monographic descriptions of the species of edible fish in the Barents Sea. The collections were made with different gears, including all kinds of nets, as well as by beam-trawl.

At the same time there have been made several hydrological sections 15—20 miles off the shore, in order to explore the conditions of existence in coastal waters.

S. Averinzev.

Current Bibliography.

Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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Note.

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